December 1998

Developing and field testing industrial prototype of wood gasifier-based silk reeling oven and other related activities

---

Final report submitted to

Swiss Agency for Development and Co-operation
New Delhi

Biomass Energy Technology Applications
Tata Energy Research Institute
New Delhi

Contents

Tables

Figures

CHAPTER 1

Background

In an earlier phase of the project, sponsored by the Swiss Agency for Development and Co-operation (SDC), Tata Energy Research Institute (TERI) had developed an improved field prototype (Mark '3') gasifier-based silk reeling oven system for cottage basin units. The unit was developed and tested at TERI's Gual Pahari campus, for assessing its reliability and maintenance requirements. After successful completion of testing, two such systems were fabricated and installed at Mr Babu and Mr Pasha unit at Ramanagaram in Karnataka for field testing-cum-demonstration. The major objective of the project was to quantify the benefits of the wood gasifier-based silk reeling basin oven system such as fuel saving, silk yield and quality improvement.

1.1 Summary of project phase-2

During the extended field testing of gasifier-based silk reeling oven system the major objective of the project, to develop and test the gasifier-based system for cottage basin silk reeling unit at traditional reeling clusters like Ramanagaram, was successfully achieved. The other objective, to quantify the benefits of the wood gasifier-based silk reeling oven over conventional system, was also achieved successfully through comparative data collection. It has statistically proved that the system saves about 50% fuel and also improves the silk yarn yield or renditta giving around 270 g (mean of 52 data points) more yarn through processing of 100 kg cocoon in a day. It was also observed that the labour productivity and working conditions are also improved due to consistent power and less smoky conditions. Improvement in silk yarn quality though observed and felt by reelers, could not be confirmed statistically. All these benefits will have great impact in improving economic viability of the system. In this phase, several design ideas were also collected from different design consultants, manufacturers and users in order to make the complete gasifier-based silk reeling oven assembly in standard modular marketable product so that it can be manufactured at centralized place and assembled at the field site without needing much civil construction work.

1.2 Objectives of current phase

After successful development and field testing, there is a need to develop an industrial prototype of gasifier-based silk reeling oven and test it in the laboratory as well as in field in order to arrive at a marketable model. Simultaneously several other non-technical issues like

developing manufacturer base, marketing and financial mechanism etc. need to be addressed. In order to widen the base for manufacturer of the gasifier-based system there is a need to explore marketing potential of gasifier-based system in other associated potential industries such as dyeing and charkha. In order to develop system for dyeing industry, the first step would be to assess market and collect necessary primary data to develop suitable design of gasifier-based system. On the basis of this design base data, development of laboratory prototype for gasifier-based silk dyeing unit can be initiated. After lab testing of system one unit would be tested for actual field in selected dyeing unit.

The major objective of the present phase of the project therefore is to develop an industrial design of gasifier-based silk reeling oven for cottage units, its field testing to arrive at marketable product. The other allied objectives of the project are to assess the potential of gasifier-based system in other silk related industry such as dyeing, charkha and collect design base data to develop suitable system.

1.3 Scope of the work

The scope of the proposed project can be categorized under the following broad headings.

- development of industrial prototype unit of the gasifier-based silk reeling oven
- field testing of the industrial prototype unit in Ramanagaram cluster
- developing manufacturing base for gasifier-based systems
- formulating marketing strategies for gasifier-based system in silk industry
- filing of patent for Mark '4' gasifier-based silk reeling oven
- design and fabrication of gasifier-based lab prototype unit for dyeing application
- installation and field testing of gasifier-based dyeing unit
- documentation of the project work and findings.

The following is the list of activities required to be undertaken in order to achieve the project objectives.

1. Review of comparative data collected so far and finalization of protocol for further testing.
2. Market assessment for price of silk from traditional cottage basin oven and gasifier-based oven system.
3. Further comparative data collection on Mark '3' till July.
4. Further improvement and lab testing of Mark '4'.

5. Design and fabrication of Mark '4A' (3–4 units).
6. Installation and field testing of '4A' at Pasha unit.
7. Installation and field testing of Mark '4A' at Babu unit.
8. Data collection on Mark '4A'.
9. Identification of consultant and preparation of Mark '4' system specifications
10. Filing of patent for Mark '4A'.
11. Pre-final selection of manufacturers.
12. Selection of marketing consultant and finalization of ToR.
13. Developing market strategies for gasifier-based systems.
14. Cluster level survey of other reeling area such as Siddlaghatta, Vijaypura etc.
15. Identify sites for further demonstration of Mark '4A'.
16. Actual installation of Mark '4A' units at selected sites for demonstration (subject to interest and capability of manufacturers).
17. Collection of experimental data on selected dyeing units to arrive at design base.
18. Design, fabrication and laboratory testing of gasifier-based dyeing unit.
19. Installation and testing of field dyeing unit.
20. Design review workshop.
21. Documentation of the work done.

Due to unavoidable reasons activities nos.18, 19, 20 & 21 could not be completed in time. Therefore, during the course of the project progress, it was decided to extend the project duration till September 1998.

This project report gives detailed work carried out in this phase pertaining to field testing of two Mark '4' gasifier systems installed in the Ramanagaram cluster, design fabrication and installation of first field gasifier-based dyeing system. The report also includes on efforts made to develop manufacturer, marketing network for test marketing.

1.4 Chronology of activities

April 1997

1. Design, fabrication of Mark '4' gasifier-based silk reeling system.
2. Preparation of Phase 2 final report.
3. Full day test runs on Mark '3' gasifier system.

May 1997

1. Testing of Mark '4' system at Gual Pahari.
2. Visit of Mr Greg Wishart to Ramangaram sites.
3. Market assessment of silk produced in gasifier system.
4. Discussion with patent attorney for filing a patent.

June 1997

1. Simulation test runs on Mark '4' system at Gual Pahari
2. Identification of system operational problems at Gual Pahari.
3. Filing of provisional patent.
4. Preparation of draft licensee agreement between TERI and manufacturer.

July 1997

1. Finalisation of design for Mark '4' gasifier-based silk reeling system.
2. Project co-ordination-cum-review meeting at SDC Bangalore involving reelers.
3. Preparation of Mark '4' gasifier drawing.
4. Visit to different dyeing cluster to collect design data.
5. Visit of SERI 2000 team to Ramanagaram.

August 1997

1. Fabrication of first field Mark '4' system at Delhi.
2. Dismentling of Hindupur gasifier system and transport of gasifier to Ramanagram.
3. Testing of Mark '4' field system at Gual Pahari.
4. Preparation of ToR for marketing consultant.

September 1997

1. Packing, transport of Mark '4' gasifier-based silk reeling system.
2. Site preparation, erection and commisisonig of gasifier-based system at Pasha unit.
3. Trial run on gasifier-based system.
4. Collection of comparative data on both traditional and gasifier ovens at Pasha unit.
5. Presentation by Mr Greg Wishart on commercialisation of gasifier systems.
6. Preparation of ToR of Prof. Bapat for further improvement in Mark '4' design.

November 1997

1. Comparative test runs on Mark '4' at Pasha unit continued.
2. Preparation of interim project report.
3. Launching of SERI-2000 programme.
4. Finalisation of design of gasifier-based system for Babu unit.

December 1997

1. Comparative test runs at Pasha unit continued.
2. Testing of second field system at Delhi.
3. Packing, transport of gasifier-based silk reeling system.

January 1998

1. Comparative test run at Pasha unit continued.
2. Site preparation, erection and commisisonig og gasifier-based system at Babu unit
3. Trial run on gasifier-based system.
4. Collection of comparative data on both traditional and gasifier ovens at Babu unit.

February 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Fabrication of laboratory prototype for gasifier-based dyeing system.

March 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Testing of laboratory prototype of gasifier-based dyeing system.

April 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Visit by Prof. Bapat to Ramanagaram.
3. Visit by marketing team to review the potential manufacturers in Bangalore and Coimbatore.

May 1998

1. Comparative test runs at Pasha and Babu units continued.

2. Visit by marketing team to review the potential manufacturers based in Delhi, Yamunanagar and Meerut.

June 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Filing of complete specification of patent.
3. SDC-TERI meeting on finalisation of ToRs for International Consultants.

July 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Detailed energy audit for selected dyeing units.

August 1998

1. Comparative test runs at Pasha and Babu units continued.
2. Second project co-ordination-cum-review meeting at Bangalore.
3. Installation of gasifier-based dyeing system at Bangalore.
4. Starting of one month independent test run by reeler.

September 1998

1. Design review workshop in Bangalore.
2. Collection of process parameter data of Channapatna unit.
3. Visit by Prof. Bapat to gasifier-based dyeing system.
4. Documentation of the project work.

CHAPTER 2

Design, development & laboratory testing of Mark '4' system

Even since the field prototype Mark '2' installed and tested at Hindupur, four basic technical problems kept popping up without satisfactory solutions. These are:

(i) high maintenance requirements in the form of cleaning the burner ports, gas lines etc.

(ii) high pressure drop across the bubbling chamber which necessitated the use of 1 hp motor and the associated kerosene engine.

(iii) environmental concerns for disposing off the tar-ladden waste water.

The system of 6 separate burners with shields and associated valves, pipes etc. was definitely unweildy especially while cleaning. The idea of having several cooking "compartments" in a single water bath presented and suggested to the reelers in several discussions and, in a more elaborate manner, during the coordination meeting held at Bangalore on 3 January 1997. It is also interesting that a similar idea was suggested by boiler manufacturers and others independently. Hence, it was decided to try a single cooking basin with multiple compartments on an experimental basis. Such a basin would require only one burner and the oven design would be immediately simplified. During project review workshop of phase 2 of the project, one such unit was demonstrated to design consultant and reelers. On receiving positive response from all participants, it was decided to go ahead with idea of using single cooking water bath with compartment while developing Mark '4' industrial prototype design.

2.1 Design of Mark '4'

During field testing, it was observed that at any given time only four out of six cooking basins were used, while the other two were used for supplying make-up hot water. Hence it was felt that the single basin in the modified oven can have only four compartments. In order to have a uniform temperature in all the compartments, a large number of holes were made on the bottom and sides of each compartment.

In the gasifier systems tested both at Hindupur and at Ramanagaram, the heat recovery drum did not achieve temperatures above 60°C. Preliminary calculations showed that heat recovery in the drum was not significant. The reasons for this could be (i) inadequate heat transfer between flue gases and water drum and (ii) low flue gas temperatures due to dilution with atmospheric air.

In order to minimize losses from the oven and to maximize heat recovery from flue gases, it was decided (i) to seal the oven completely, (ii) to provide mineral wool insulation and (iii) to provide a large heat transfer area by installing a number of flue pipes inside the heat recovery drum. Also, the drum was connected to the cooking basin via a float valve, so that whenever the water level in the cooking basin drops down due to evaporation and process water carry over loss, it is automatically compensated by supply of hot water from the drum. This would eliminate the need for physically pouring water into the cooking basins by one of the workers, thus saving labour and, more importantly, reducing wastage of water.

The bubbling chamber can be avoided if the raw gas can be burnt directly. This would also give a better thermal efficiency as volatile organic matter will also be burnt and the sensible heat in the gases will not be lost. The main hindrance for doing so was that the tar and particulate matter would deposit inside the pipeline and would ultimately block the passage. After considerable thinking, it was decided to replace the GI pipeline with an insulated duct with a large rectangular cross-section. The insulation would keep the gases hot, thus avoiding condensation of tar and the large rectangular cross-section would allow the dust particles to settle down, besides reducing the overall pressure drop. The entire duct can be cleaned by opening a dummy flange provided on the other side of the duct. The detailed procedure of Mark '4' prototype designing is given in following section .

2.1.1 Alternative cooking oven design basis

To arrive at new cooking basin design, a heat transfer area calculation of the present cooking system were made as follows:

1.	Total number of cooking pots (n)	:	6
2.	Diameter of pot (d)	:	23 cm
3.	Height of pot (l)	:	20 cm
4.	Total pot bottom area exposed to flame (A_r)	:	$n \times \pi/4 \times d^2 = 1,885$ cm^2
5.	Total side area of pots (A_c)	:	$n \times \pi$ dl $\times 6 = 6,786$ cm^2
6.	Total pot area	:	$A_r + A_c = 8,679$ cm^2
7.	Volume of each pot (V_p)	:	7,000 cm^3
8.	Total volume of cooking pot	:	$n \times V_p = 42,000$
9.	Exposed radiation area/volume ratio	:	1,885/42,000 = 0.044

In new cooking oven basin design calculation, basic process data collected during field testing at Ramanagaram data were used. The incoming and outgoing stream of present cocoon processing is given in Figure 1.

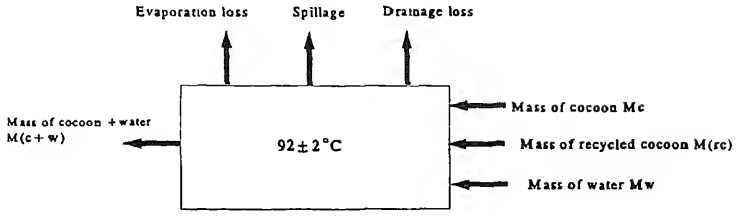


Figure 1. Incoming and outgoing streams of cocoon cooking process

The details of typical values are:

M_w (mass flow rate of water)	:	65 kg/h
M_c (mass flow rate of fresh cocoon)	:	12 kg/h
M_{rc} (mass flow rate of recycled cocoon)	:	68 kg/h
$M_{(c+w)}$ (mass flow rate of cooked cocoons and water)	:	140 kg/h

2.1.1.1 Cocoon cooking process parameter

During the field testing of Mark '3' gasifier-based system at Ramanagaram extensive data was collected regarding the cocoon cooking process. It was observed that in each cooking cycle per pot, average 70-80 g fresh cocoon were taken along with recycled cocoon (total weight 450–550 g) and is cooked for 60 second. After cooking, the cocoon along with water weighing 700–800 g were taken out from the pot and delivered to reeling basin by the cooker himself. The cooker will come back for next cooking within 30 seconds. At any given time four cookers cook the cocoons simultaneously. Therefore, total of 300 g of fresh cocoon cooked per 90 seconds equivalent to 12 kg/h cocoon processing rate. On the basis of these process parameters Mark '4' gasifier-based system is designed.

2.1.1.2 Water consumption

Water loss during the cocoon cooking process is mainly by drainage loss, evaporation loss and spillage loss. The water loss under different heads are observed and recorded as follows:

Drainage loss	:	1.5 kg/h
Evaporation loss	:	0.40 kg/h
Spillage loss	:	3.10 kg/h
Total loss	:	5.00 kg/h

2.1.1.3 Initial power (P_i)

Cooking oven — Before start of actual cooking, water in each cooking pot is used to boil from 20°C to 90°C within 30 minutes. At the same time 180 l water in the heat recovery unit is also needed to be heated from 20 to 50°C to supply warm water to 10 reeling basins.

$$P_{ia} = n \times V_p \times (\Delta T) \times 60/(t \times 860) = 9.75\ kW_{th}$$

$$P_{ib} = 180 \times (50-20) \times 60/(30 \times 860) = 12.6\ kW_{th}$$

The initial power requirement of the cooking oven works out to 9.75 kW_{th} and power at HRU (Heat Recovery Unit) to 12.6 kW_{th}.

Therefore, total initial power is $P_i = P_{ia} + P_{ib} = 22\ kW_{th}$

2.1.1.4 Running power (P_r)

The total thermal energy requirement during actual cocoons cooking is calculated as follows.
Power of cooking oven (P_c) — Each cooker will cook average total of 500 g of (fresh cocoons and recycled) cocoons in 90 seconds. At a given time, 4 cookers will cook the cocoons. Total weight of cocoons cooked in the cooking bath is 2,000 g. Therefore, total thermal energy required to cook the cocoon assuming specific heat of cocoon (C_p) same as water will be:

$$P_c = \frac{C_p \times (M_c + M_{rc})\ (\Delta T) \times 60}{t \times 860} = 6.5\ kW_{th}$$

where M_c is mass of fresh cocoon, M_{rc} mass of recycle cocoons, ΔT is rise in temperature from 20 to 92°C and t is time for cooking for 1.5 minute.
Power of heat recovery unit (P_{hru}) — The heat recovery unit is designed to supply 65 l/h of water at 90°C to cooking oven. Therefore, power of HRU is

$$P_{hru} = \frac{C_p \times M_w\ (\Delta T)}{860} = 5.3\ kW_{th}$$

where, M_w is the water flow rate (65 l/h), ΔT is rise in temperature from 20 to 90°C.

$$P_r = P_c + P_{hru} = 6.5 + 5.29 = 12\ kW_{th}$$

Therefore, total running power of the system is 12 kW. During starting up period, the gasifier needs to supply 22 kW_{th}, useful heat and during the actual cooking process, the gasifier needs to supply only 12 kW_{th} of process heat.

2.1.1.5 Cooking oven design

The cooking basin dimensions are arrived at so as to accommodate 4 cookers at workable separation distance between them and at the same time keeping total volume of the basin to minimum. The dimension of cooking oven arrived is 600 mm (L), 500 mm (B), and 250 mm (H). Heat transfer in cooking oven is mainly by radiation from flame to exposed bottom of vessel. The total exposed area of cooking oven is 3,000 cm^2. Volume of water in cooking bath is 60 l. Therefore area/volume ratio is 0.05.

Heat transfer in the heat recovery unit is mainly by conduction and convection between flue gas and water. Total useful power required is 5,290 W_{th}. In order to achieve this, the surface area requirement is calculated as below:

$$P_{hru} = h \times A \times t$$

where h = heat transfer coefficient between flue gas and water (assumed 5 kCal/hr m^2°C)
A = area in m^2
t = logarithmic mean temperature difference between flue gas and water (180°C)

$$A = \frac{5290}{15 \times 180} \simeq 2\ m^2$$

In order to have 2 m^2 heat transfer area, 2" ϕ SS tubes were used in the HRU. The total number of tubes required is calculated as follows:

$$A = n \times \pi \times d \times l$$

where n is the number of tubes, d is diameter of tube (0.05 m), l is length of tube (0.8 m).

$$n = \frac{2}{\pi \times 0.05 \times 0.8} \simeq 16$$

The total number of tubes required for effective heat recovery works out to 16. In order to supply hot water from HRU to cooking oven, a float valve arrangement is made so

that water level in the cooking oven is always maintained at the constant level. This design improvement reduces one manpower which is required for water management purpose in conventional oven. A temperature indicator is also placed in the system to allow cooker to know the cooking water temperature. This new system design has the following advantages:

1. No need for manpower to supply hot water from HRU to vessel.
2. All the cooking pot will remain at the same temperature and constant water level.
3. Large thermal mass of water minimizing the variation in the water temperature during cooking process..
4. Indication for water temperature

Based on the above design, a detailed system drawing is prepared. The same is given to M/s Urjex Boilers for fabrication.

2.2 Further improvement of Mark '4'

The first Mark '4' system was installed and operated at the Gual Pahari on 11 March 1997. Subsequently a design review workshop was held at Delhi on 13–14 March 1997 in which all the participants, including the reelers, visited the Gual Pahari. Reeler also cooked the cocoons using the new system. Their immediate observations about Mark '4' unit were:

1. The vapours/steam coming out of the cooking vessels appear to be in excess.
2. Working height of the cooking basin needs to be reduced.
3. The cooking vessel diameter needs to be increased to 9".
4. The working space or distance between two vessels is less.
5. The vessels and drum must be made out of copper.
6. Power level needs to be reduced.
7. Radiation from the metal cover is high due to higher surface temperature.

Following advantages of the new Mark '4' system were appreciated by participants over Mark '3'

1. Easy cleaning.
2. Absence of bubbling chamber will occupy lesser space.
3. Less number of bends and joints will help in reducing pressure drop.
4. System appears simple.

5. With the same amount of fuel, it may be possible to increase the number of cooking vessels, increase the number of reeling basins and process larger quantities of cocoon.

Based on the feedback received during demonstration in the design review workshop, the following modifications were incorporated in the Mark '4' unit at Gual Pahari.

1. The blower capacity is reduced to 0.5 hp from present 1 hp capacity. A centrifugal blower of Azad make is procured and coupled with the system.
2. The number of holes were made on the periphery of the each vessel in order to have uniform temperature in all the vessels.
3. The temperature sensor (PT 100) is placed at the main vessel and connected to data logger for recording the water temperature.

2.3 Laboratory testing of Mark '4'

After modifications in the Mark '4' system at Gual Pahari laboratory testing of the system was done. The simulation condition was achieved at laboratory by adding and removing water from cooking basin. About 2000 g of cold water equivalent to weight of cocoons is added into the vessel. After 60 sec 3000 g of hot water equivalent to cooked cocoons weight is removed from the vessel. Then after 30 sec 2000 g of cold water is added on the vessel for next cycle. During this simulation cycle temperature of water in the cooking vessel is recorded every 30 sec. Time temperature curve is plotted for entire duration of testing and the wood consumption during this period is also noted. The typical time temperature curve is given in Figure 2 a&b. It can be seen from the figures that the temperature of the water is maintained throughout the batch at 92±2°C. Probably, this will further help in improving and maintaining uniformity in silk yarn quality during actual cooking. There is no major modification made in the gasifier design of Mark '4'.

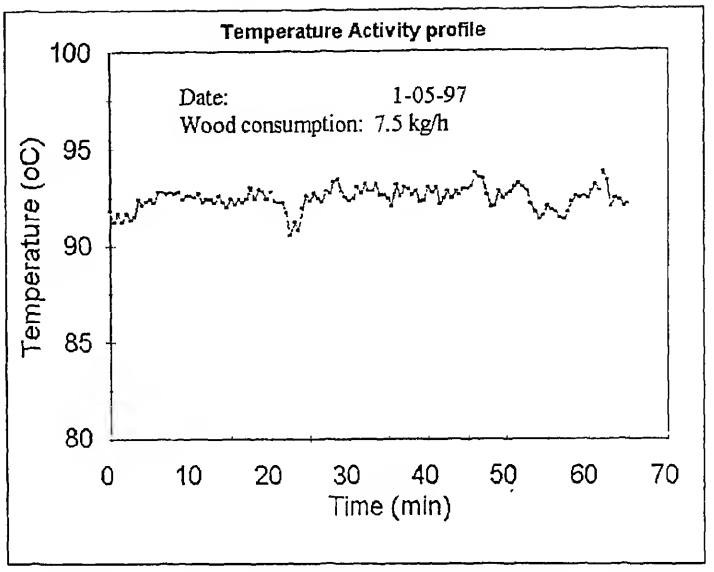


Figure 2a. Time, temperature profile of Mark '4' cooking oven during laboratory testing

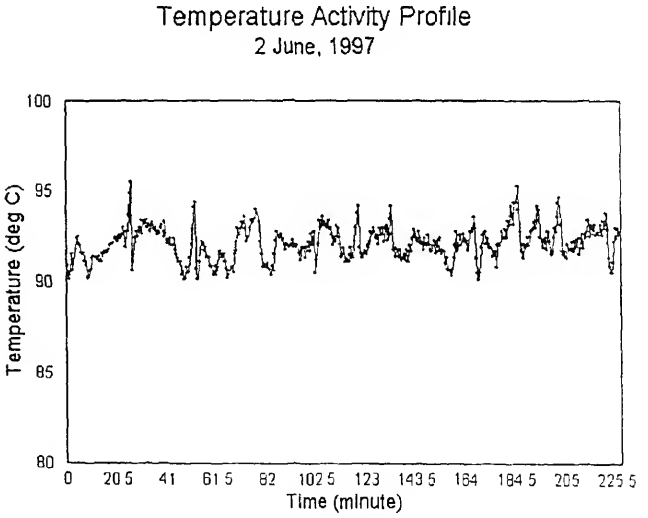


Figure 2b. Time, temperature profile of Mark '4' cooking oven during laboratory testing

2.4 Installation and field testing of Mark '4' at Pasha unit

After incorporating all the modification suggested by the reelers in the design review workshop, and subsequently successfully testing the system at Gual Pahari, the drawing for the first field system is prepared as shown in Figure 3. The modified cooking oven drawing is given to M/s Urjex Boiler for fabrication. The copper drum of 280 l and four cooking vessels is purchased from Bangalore and rest all fabrication is carried out at workshop in Meerut. After complete fabrication and assembly of the cooking oven, the system is transported to Gual Pahari on 29 August 1997. The cooking oven is coupled with the existing gasifier and tested at Gual Pahari for about a week under simulated field conditions. Later the cooking oven was transported to Ramanagaram by road transportation. The cooking oven reached Ramanagaram via Bangalore on 13 September 1997. The gasifier installed at Hindupur is taken back to Ramanagaram due to closure of the unit. The same gasifier after few modifications is coupled with the new cooking oven. The Mark '4' gasifier system was installed and operated at Pasha unit on 14 September 1997. First trial run on the system is made on 17 September 1997. The summary of the test run is given in Table 1.

Table 1. Summary of first test run data at Pasha's unit (17.09.97)

Items	*Cottage basin*	*Gasifier basin*
Total cooking time	4 h 30 min	4 hrs 5 min
Total cocoons processed	40 kg	45 kg
Wood consumed	-	37.5
Silk produced	3.49	4.05
Sp. fuel consumption kg/kg of cocoon	-	0.83
Renditta (kg of cocoons per kg of silk)	11.46	11.11
No. of persons cooking	4	5
Cocoon processing rate	8.89 kg/h	11.0 kg/h

A photograph of the new system installed at Mr Pasha premises is given in Figure 4. The temperature of the cooking water is recorded through data logger during cooking operation in the new system. The similar temperature profile data is also recorded for one of the vessel in the conventional oven for comparison. The data is plotted and shown in Figure 5 a&b. The temperature of the cooking water in gasifier system is always maintained between 93 to 97°C throughout the cooking whereas in conventional cooking water temperature varies between 80–100°C apart from the individual variation of the each cooking pots. After successful trial runs at Pasha unit the regular comparative test runs were started.

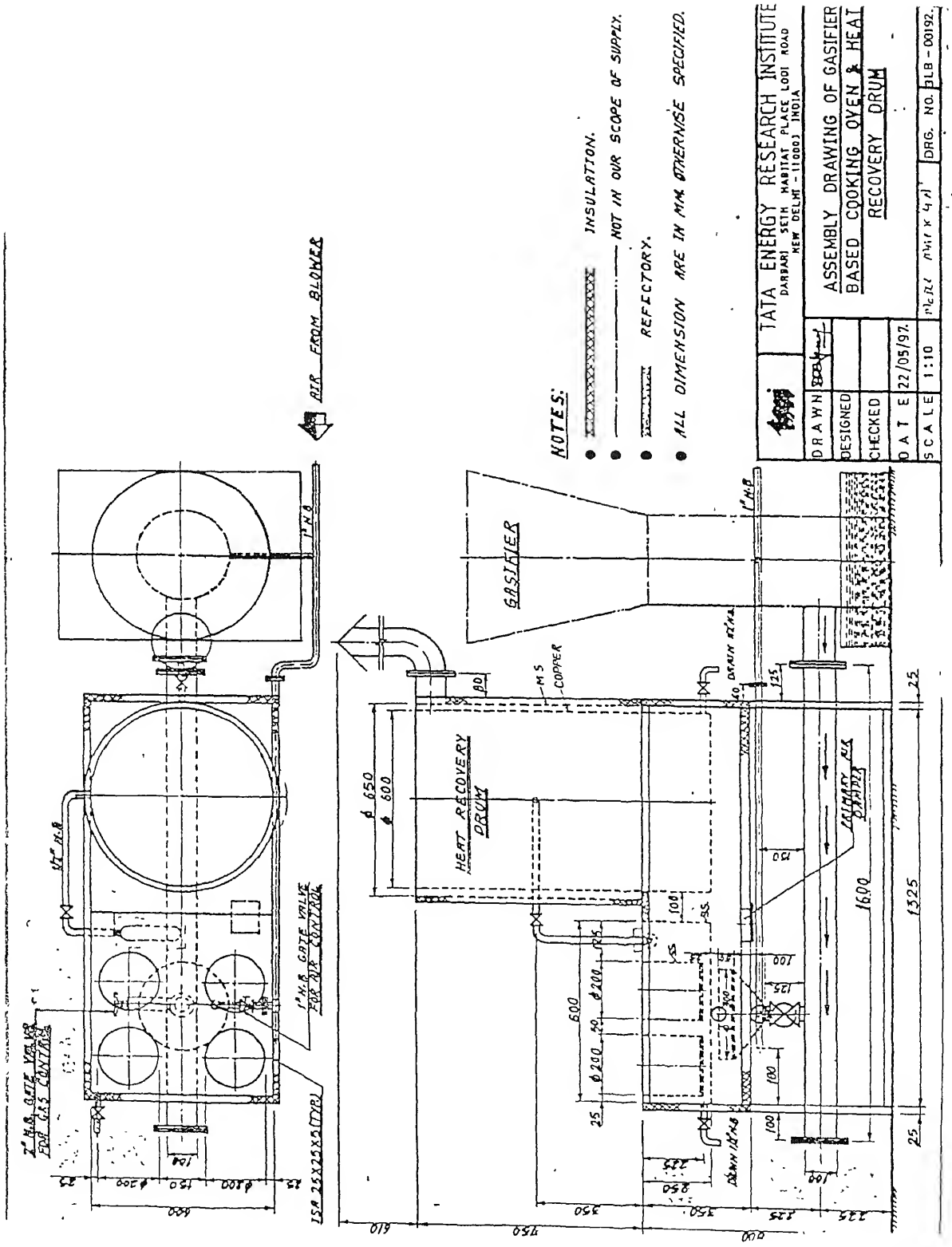


Figure 3. Detailed drawing of Mark '4' system installed at Pasha unit

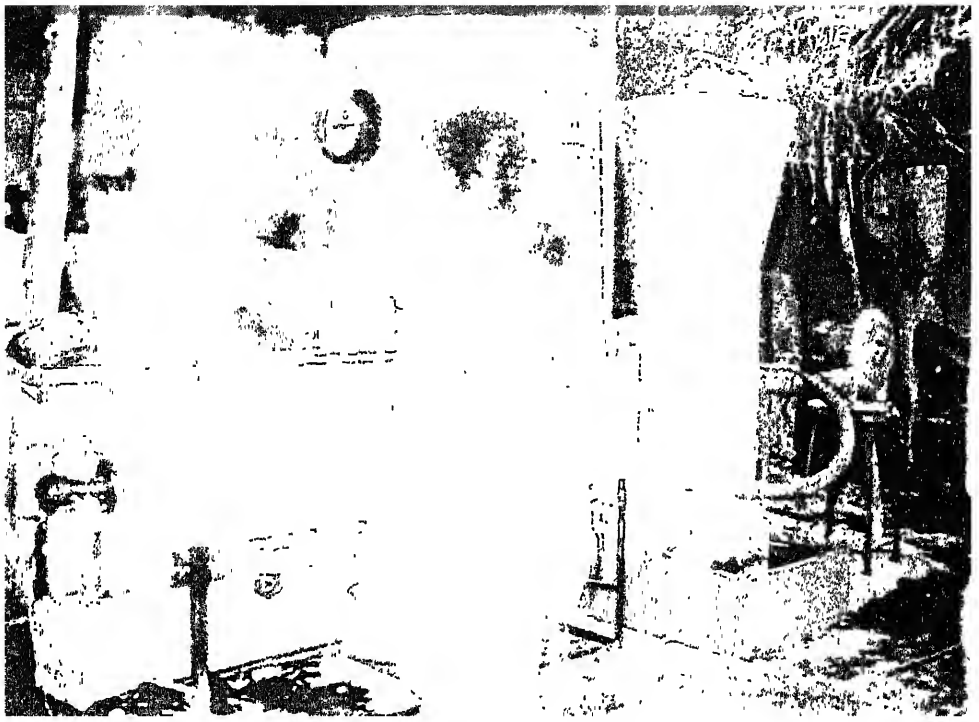


Figure 4. Photograph showing Mark '4' gasifier system at Pasha unit

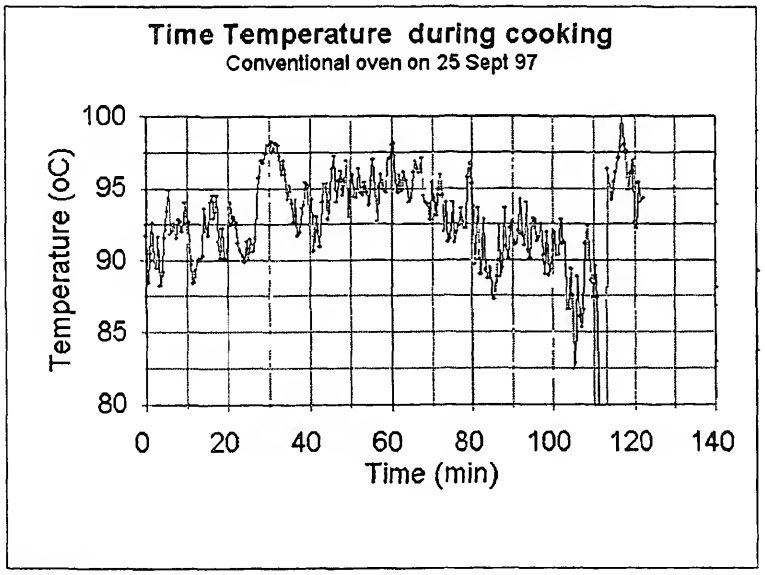


Figure 5a. Time, temperature profile during cocoon cooking in conventional oven

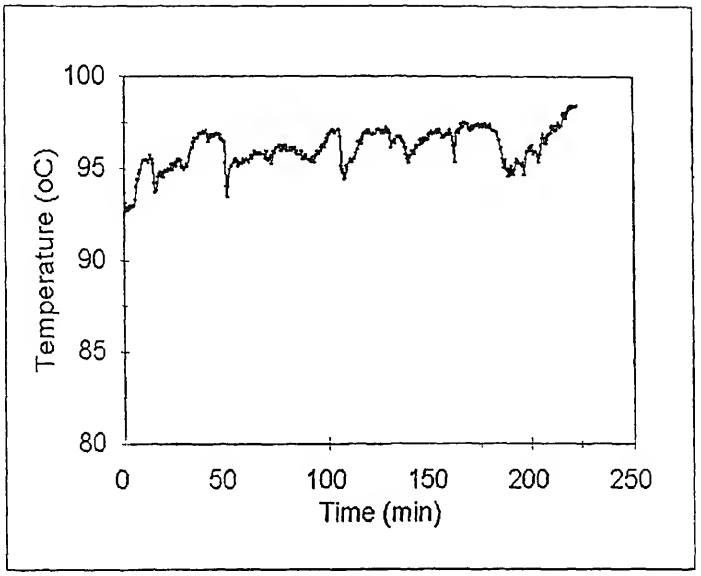


Figure 5b. Time, temperature profile during cocoon cooking in Mark '4' gasifier system

2.5 Installation and field testing of Mark '4' at Babu unit

After stabilizing the operation of first field system at Pasha unit the fabrication of the second system was initiated. It was observed during testing of Mark '3' system that the specific water consumption (amount of water required per kg of cocoon) in Babu unit is about half compare to that in Pasha unit. The idea of SS heat recovery drum having flue gas tubes in the centre is suggested to Mr Babu. Later, a new cooking oven drawing were prepared and given to Urjex Boiler for fabrication. The drawing of the Babu system is given in Figure 6. After the cooking oven was fabricated and tested at manufacturers site by TERI, the unit was sent to Ramanagaram by road transport. The new cooking oven was coupled with the existing gasifier installed and operated at Babu unit on 15 January 1998. First trial run on the system is made on 19 January 1998. The summary of the test run is given in Table 2. The photograph of the system is shown in Figure 7.

Table 2. Summary of first test run at Babu's unit (19.01.98)

Items	*Cottage basin*	*Gasifier basin*
Total cooking time	3 h 30 min	3 hrs 15 min
Total cocoons processed	36 kg	36 kg
Wood consumed	74	30
Silk produced	3.85	4.15
Sp. fuel consumption kg/kg of cocoon	2.05	0.83
Renditta (kg of cocoons per kg silk)	9.35	8.67
No. of persons cooking	4	4
Cocoons processing rate	10.3 kg/h	11 1 kg/h

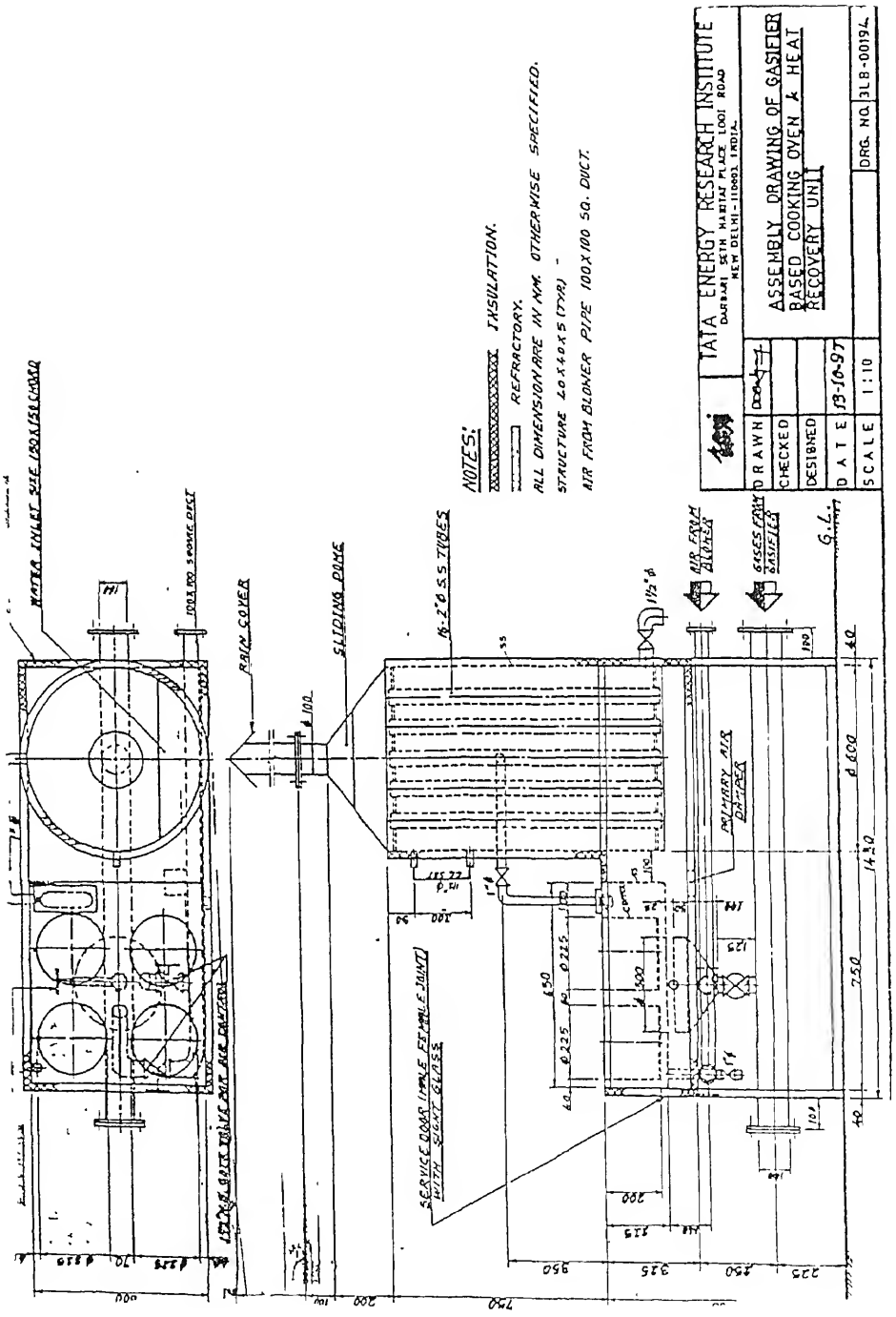


Figure 6. Detailed drawing of Mark '4' system installed at Babu unit

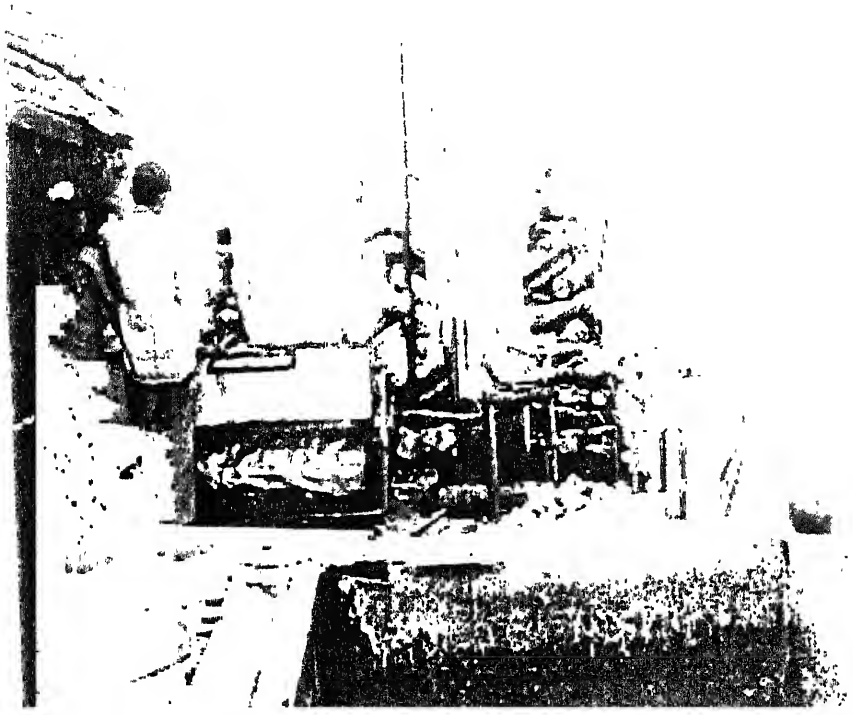


Figure 7. Photograph showing Mark '4' gasifier system at Babu unit

CHAPTER 3

Field data collection and analysis of gasifier-based system

After stabilizing the operation of gasifier-based Mark '4' system at Ramanagaram experiments were conducted for comparative testing of the gasifier systems in order to quantify the benefits of the gasifier system over conventional system. For this purpose, data on the parameters like wood consumption, silk yield, cocoon processing rate and water consumption was collected on both gasifier and conventional oven. In order to assess the quality of silk yarn, the samples of silk yarn were collected and tested from recognized laboratory.

In this chapter, the methodology adopted for data collection along with details of actual data is given. The chapter also discussed the statistical significance of different benefits.

3.1 Methodology of data collection

For the purpose of comparative data collection, the whole lot of cocoon is uniformly mixed and is divided into two lots. One lot is processed in the conventional oven and other in gasifier oven. The data like cocoon processed, wood consumed, silk produced and cocoon processing time is recorded for both the lots. In order to prove the benefits of the gasifier system statistically and to reduce variance it was planned to conduct a minimum of 30 comparative tests on each system. In order to have similar operating conditions during testing the operation of gasifier and conventional oven is shuffled between first and second batch. The format for collection of field data is designed and given as an Annexure 1.

3.2 Summary of data for wood consumption

In all about 39 comparative tests were conducted to assess the wood saving in Pasha unit and 25 tests runs in Babu unit. The data for wood consumption is recorded and based on that specific fuel consumption (wood consumption per kg of cocoon) is calculated and given in Table 3. It can be seen from the data that specific fuel consumption varies from 1.98 to 3.33 kg/kg of cocoon for conventional oven and 0.72 to 1.26 kg/kg of cocoon for gasifier system at Pasha unit. In case of Babu unit, specific fuel consumption varies from 1.70 to 2.24 kg/kg of cocoon for conventional oven and 0.72 to 1.04 kg/kg of cocoon for gasifier system. An average wood saving of 60.5% was observed for both the units.

Table 3. Summary of comparative specific fuel consumption data

Sr. No.	Pasha unit			Babu unit		
	Conventional	Gasifier	% difference	Conventional	Gasifier	% difference
1.	2.18	0.83	61.7	2.06	0.83	59.5
2.	2.13	0.78	63.2	2.10	0.91	56.8
3.	3.33	1.09	67.3	2.38	0.84	59.3
4.	2.78	1.08	61.4	1.70	0.75	55.9
5.	2.68	1.10	58.9	1.81	0.83	53.8
6.	2.65	1.09	59.0	2.00	0.80	58.9
7.	3.09	0.80	74.2	2.12	0.93	56.1
8.	2.38	0.89	62.6	2.24	1.00	55.4
9.	2.45	1.00	59.2	2.13	0.79	62.7
10.	2.45	1.09	55.6	2.13	0.85	59.9
11.	2.53	0.99	60.9	2.21	1.04	53.0
12.	2.63	0.90	65.7	2.08	0.86	58.8
13.	2.68	0.78	70.9	2.06	0.95	53.9
14.	2.47	0.96	61.0	2.03	0.89	64.1
15.	2.92	0.93	68.2	2.06	0.92	55.4
16.	2.64	0.96	63.9	1.83	0.72	60.6
17.	3.20	0.93	70.8	2.06	0.89	57.0
18.	2.60	1.05	59.6	1.92	0.75	60.9
19.	3.27	1.20	63.3	1.82	0.85	53.3
20.	2.73	1.00	63.3	1.89	0.83	53.8
21.	2.70	0.71	73.6	1.94	0.81	58.6
22.	2.88	0.96	66.8	2.00	0.76	62.0
23.	3.00	0.88	70.8	1.86	0.69	62.7
24.	2.93	1.01	65.4	1.94	0.78	60.0
25.	3.10	1.33	57.0	2.11	0.97	53.9
26.	2.58	0.98	62.1	1.86	0.94	49.5
27.	2.94	1.26	57.0	1.81	0.83	54.2
28.	2.44	0.98	60.0	1.97	1.00	49.2
29.	2.83	1.23	56.6	1.89	0.99	47.6
30.	2.63	1.15	56.2			
31.	2.60	0.98	62.4			
32.	2.79	1.14	59.1			
33.	2.75	1.18	57.0			
34.	2.09	0.76	63.8			
35.	2.84	0.84	70.4			
36.	2.14	1.00	53.1			
37.	2.15	0.85	60.5			
38.	2.03	0.96	52.6			
39.	1.98	0.72	63.6			
Average	2.64	0.98	62.5	2.0	0.87	57.6

3.2.1 Statistical analysis of fuel saving

The statistical Z-test analysis of all the 68 data points is done at 95% and 99% confidence

level. The Z-test results are given in Table 4. The 59.7% and 59.2% reduction in specific fuel consumption was observed at 95% and at 99% confidence level respectively indicating substantial fuelwood savings.

Table 4. Z-test analysis: reduction in specific fuel consumption

Level of significance	Critical value of Z for one tailed test	% reduction in specific fuel consumption
95%	1.645	59.2
99%	2.330	58.8

3.3 Summary of data for silk yarn yield (Renditta)

The other observed major benefit of the gasifier system is higher silk yarn yield or lower value of renditta (amount of cocoon required to produce 1 kg of silk). In total about 82 comparative tests were conducted to assess silk yarn yield, out of which about 48 tests were carried out in Pasha unit and 34 test in Babu unit. The percentage extra silk obtained in gasifier system is calculated and tabulated data is given in Table 5. It can be seen from the table that percentage extra silk yarn yield obtained in Pasha unit varies from 0.6 to 8.6% whereas in case of Babu unit it varied from 1.0 to 8.0%.

Table 5. Summary of silk yarn yield data (Renditta)

Sr No.	Pasha unit			Babu unit		
	Conventional	Gasifier	% difference	Conventional	Gasifier	% difference
1.	8.73	9.01	3.3	10.69	11.53	7 8
2	9.67	10 09	4.4	11 62	11.93	2 6
3.	9.89	10.13	2.5	11.84	12.55	5 9
4	10 00	10.18	1.8	10 46	11.24	7 4
5.	7.62	7.91	3.8	11.43	11.89	4.1
6	10 15	10 22	0 6	12.07	12.40	2 7
7	10.40	11.10	6.7	12.17	12.60	3 6
8	10.43	10 83	3 8	10.85	11.19	3 1
9	10.89	11.61	6.6	7.80	8.20	5 1
10	9.44	9 91	4.9	11.54	12.03	4 2
11	10 70	10 98	2.5	11.51	11.89	3.3
12	11 10	12.03	8 3	10.70	11.15	4.2
13	10.55	10.98	4.0	11.45	11.72	2.3
14	11 28	12 08	7 1	11.30	12.04	6.5
15	11.55	11.62	0.6	12.05	12.54	4 1
16	10.36	11.00	6 2	11.43	11.94	4.4
17	9 22	9.53	3.3	11.22	11.62	3.5
18	8.62	9.18	6 4	11.21	12.00	7.1
19	7 78	7.91	1.7	12 24	12 71	3.9
20	9 68	10 23	5.6	12.19	12.73	4 4

Sr. No.	Pasha unit			Babu unit		
	Conventional	Gasifier	% difference	Conventional	Gasifier	% difference
21.	5.97	6.47	8.3	12.08	12.46	3.1
22.	9.53	9.68	1.6	12.78	12.90	1.0
23.	9.84	10.44	6.1	12.14	13.11	8.0
24.	8.15	8.42	3.2	10.88	11.54	6.0
25.	7.23	7.36	1.0	11.15	11.47	2.8
26.	8.76	9.05	3.2	10.79	11.23	4.0
27.	9.95	10.32	3.8	11.81	12 22	3.5
28.	10.15	10.40	2.4	11.90	12.08	1.5
29.	9.60	9.97	5.8	8.85	9.21	4.1
30.	8.51	8.83	3.7	10.38	10.79	3.9
31.	9.55	10.07	5.4	10.56	11.11	5.2
32.	7.47	7.68	2.8	10.69	11.28	5.4
33.	10.02	10.58	5.5	10.88	11 74	7.9
34.	9.87	10.46	5.9	11.92	12.18	2.2
35.	9.02	9.76	8.2			
36.	9.74	10.58	8.6			
37.	10.51	10.94	4.1			
38.	10.65	11.18	4.9			
39.	11.81	12.52	6.0			
40.	11.52	11.86	3.0			
41.	12.00	12.19	1.57			
42.	10 64	11.33	6.5			
43.	11.24	11.36	1.0			
44.	10.77	11.06	2.6			
45.	9.56	9.74	1 9			
46	11.11	11.71	5 4			
47.	10.36	10.60	2.3			
48.	11.02	11.45	3.8			
Average	9.85	10.26	4.23	11.25	11.74	4.34

3.3.1 Statistical analysis of silk yarn yield improvement

The statistical Z-test analysis of all the 82 data points is carried out at 95% and 99% confidence level and the result is given in Table 6. The percentage improvement in silk yield in case of gasifier system achieved is 3.9% at 95% confidence level and 3.7% at 99% confidence level. Thus the improvement is significant and contribute towards enhancing the profitability of the reeling operation.

Table 6. Z-test analysis: silk yield improvement

Level of significance	Critical value of Z for one tailed test	% improvement in silk yield
95%	1 645	3 9
99%	2 33	3.7

3.4 Summary of data for cocoon processing rate

It was observed during field testing of Mark '3' system that the cocoon processing rate is increased in gasifier system. During Mark '4' comparative tests runs cocoon processing rate parameter is also monitored. The increase in cocoon processing rate will give an opportunity to reeler to process more cocoons in a day. Total of 67 tests runs were conducted in both Pasha and Babu unit. The summary of the processing rate data for both conventional and gasifier system of Babu and Pasha unit along with the percentage difference in the cooking processing rate is given in Table 7. It can be seen that cocoon processing rate varies from 9.36 to 16.55 kg/h for gasifier operation and 8.4 to 14.59 kg/h for conventional oven in case of Pasha unit. While in case of Babu unit the cocoon processing rate varies from 6.52 kg/h to 11.37 kg/h for conventional oven and for gasifier operation varies from 8.57 to 12 kg/h.

Table 7. Summary of cocoon processing rate (kg/h)

Sr. No.	Pasha unit			Babu unit		
	Conventional	Gasifier	% Improvement	Conventional	Gasifier	% Improvement
1.	8.89	11.02	2.13	10.29	11.08	0.79
2.	12 56	13.58	1.02	8.79	10.02	1.23
3.	13.50	15 88	2.38	8.59	10.71	2.12
4.	13.95	17.47	3.52	8.82	9.71	0.90
5.	9 16	12 57	3 41	10.05	11.08	1.03
6.	10.83	11.72	0 89	10.80	12.00	1.20
7.	12 00	12 31	0.31	7.98	9.16	1.18
8.	12.63	14.12	1.49	6.52	8.57	2.05
9	9.77	13 20	3.43	9.45	10.80	1.35
10.	12 27	13.50	1.23	9.69	9.89	0.20
11	12 63	14.55	1.91	9.45	10.33	0.88
12	10.21	12.97	2.76	9.95	10.50	0.55
13.	11.43	13.33	1.90	9.00	10.50	1.50
14	11.71	12.97	1.27	10.05	10.80	0.75
15	11.71	13.85	2.14	9.00	9.30	0.30
16	12.86	14.55	1.69	11.08	11.37	0.29
17	10.50	12.78	2.28	9.19	9.26	0.07
18.	12.56	13.85	1.29	8.76	9.43	0.67
19	10 21	13.50	3 29	10.05	11.18	1.13
20	9.73	11.25	1.52	9.60	11.08	1.48
21	12.31	14.55	2.24	9.19	10.50	1.31
22	13.33	15.74	2 41	11.37	12.00	0.63
23	12 87	16.45	3.58	10.05	10.80	0.75
24	14 12	15.00	0.88	10 05	10.29	0.24
25	12 63	14.36	1.73	11.37	12.00	0 63
26	11 25	12.00	0 75	10.29	11.08	0 79
27.	13.33	16.55	3 22	8.47	10.54	2 07
28	9 77	10 74	0.97			

Sr. No.	Pasha unit			Babu unit		
	Conventional	Gasifier	% Improvement	Conventional	Gasifier	% Improvement
29.	11.02	15.88	4.86			
30.	10.77	12.73	1.96			
31.	10.08	13.37	3.29			
32.	11.74	12.27	0.53			
33.	8.40	9.69	1.29			
34.	9.06	9.36	0.30			
35.	10.80	11.21	0.41			
36.	10.84	11.66	0.82			
37.	12.00	13.85	1.85			
38.	12.27	13.17	0.90			
39.	14.59	15.43	0.83			
40.	13.85	14.05	0.21			
Average	11.60	13.43	16.20	9.55	10.52	10.66

3.4.1 Statistical analysis of improvement in cocoon processing rate

A Z-test analysis conducted to find out the improvement in the cocoon processing rate in the gasifier-based system over conventional system indicated an improvement of 12% and 11% at the confidence level of 95% and 99% respectively. Thus the improvement are statistically significant. The result of the Z-test analysis is given in Table 8.

Table 8. Z-test analysis: improvement in cocoon processing rate

Level of significance	Critical value of Z for one tailed test	% improvement in cocoon processing rate
95%	1.645	12
99%	2.33	11

3.5 Summary of water consumption data

During Mark '4' testing it was observed that the water consumption in gasifier system is reduced because of automatic supply of hot water from the heat recovery unit to main cooking vessel. Simultaneously, due to higher volume of main vessel the water loss due to spillage and during cocoon stirring is reduced. A few tests were carried out to monitor and compare the water consumption levels in gasifier and conventional oven. For this purpose, a 200 liter drum was placed near the cooking oven and water is used for both cooking and reeling basin from the drum only. About 8 tests of measurement were made for water consumption.

Based on the water consumption monitored for a batch operation, the quantity of water required to process 100 kg of cocoon is calculated. Based on the data, the water consumption varies from 2750 to 3311 liter per 100 kg of cocoon for conventional oven whereas for gasifier system water consumption varies from 1467 to 2675 liter per 100 kg of cocoon. The data of all the test measurements is given in Table 9. It can be seen in the table that on an average of 860 liter water is saved for cooking 100 kg of cocoon.

Table 9. Summary of water consumption data

Sr. No.	Water consumption for 100 kg of cocoons (lit)		Water saved in gasifier oven (lit)
	Conventional	Gasifier	
1.	2750	1911	839
2.	2959	1837	1122
3.	3250	1467	1783
4.	2750	2225	525
5.	3250	2275	975
6	3311	2530	782
7.	2842	2399	443
8.	3086	2675	411
Average	3025	2165	860

3.6 Summary of data for silk yarn quality

The test results and analyses have shown that the silk yarn produced on Mark '4' system is of better quality. The difference in quality is statistically significant. The overall summary of test results is presented in Table 10. On the basis of the average size of the yarn, the samples were grouped as 14/16, 16/18 group, 18/20, 20/22 group and 22/24, 24/26 group. In all denier groups, figures of Quality Parameter are better for gasifier silk in both Pasha unit and Babu unit. Quality of silk yarn produced on the Mark '4' system has proved to be better.

Table 10. Summary of silk quality test results

Sr. No.	Particulars	14/16, 16/18 Group		18/20, 22/22 Group		22/24, 24/26 Group	
		Conventional	Gasifier	Conventional	Gasifier	Conventional	Gasifier
1.	Winding breaks	18 81	16.88	18.11	13.58	20.38	13.88
2.	Average size	16.85	16.22	20.03	20.40	22.38	22.24
3.	Size deviation	2.23	1.82	3.22	2.28	3.67	2.74
4	Maximum deviation	3.33	2.70	4.69	3.47	5.36	4.18
5.	Average cleanness %	86.13	89.19	77.16	82.32	76.13	80.88
6.	Average neatness %	81.88	85.44	79.74	83.47	78.38	82.50
7.	Average low neatness	75.06	78.94	71.84	75.84	71.00	74.63
8	Tenacity gms/den	3.21	3.28	3 20	3 35	3 38	3 48
9	Elongation %	15.00	15.52	13.95	15.75	14 80	15.65
10	Cohesion	21 56	28 63	21.37	32 95	24.25	27 38

Babu unit

Sr. No.	Particulars	14/16, 16/18 Group		18/20, 22/22 Group		22/24, 24/26 Group	
		Conventional	Gasifier	Conventional	Gasifier	Conventional	Gasifier
1.	Winding breaks	15.86	11.29	16.97	13.61	14.33	13.67
2.	Average size	16.51	16.61	20.32	20.08	23.81	22.75
3.	Size deviation	2.19	1.92	3.29	2.55	3.99	2.97
4.	Maximum deviation	3.03	2.74	5.15	3.75	5.47	4.50
5.	Average cleanness %	84.43	89.86	83.58	85.68	83.33	83 67
6.	Average neatness %	84.43	86.29	83.13	86.26	81.00	86.33
7.	Average low neatness	75.86	81.57	76.55	79.77	72.67	78.33
8.	Tenacity gms/den	3.34	3.51	3.45	3.52	3.46	3.26
9.	Elongation %	15.84	16.24	15.73	15.99	16.40	17.80
10.	Cohesion	23.71	43.43	33.00	32.58	29.00	25.67

Summary of the results indicated in the tables above is as follows:

- Winding breaks are fewer for the yarn produced on the Mark '4' system, indicating that there would be faster and more efficient processing at the twisting stage, producing lesser wastage during twisting.
- Coefficient of variation for the denier deviations is lower for the yarn produced on the Mark '4' system indicating that this yarn is more uniform compared to the yarn produced on the conventional system.
- Standard deviation of size and Maximum deviation of size emphasize the fact that the yarn produced on the Mark '4' system is comparatively more uniform.
- The cleanness and neatness values have indicated that the silk yarn produced on the Mark '4' system has fewer defects, slugs or knots when compared to the silk yarn produced on the conventional system.
- The tenacity has also improved in the yarn produced on the Mark '4' system as compared to the yarn produced on the conventional system.

The detailed report on silk quality testing will be given in supplementary volume.

CHAPTER 4

Economic analysis of gasifier-based silk reeling oven (Mark '4')

The detailed economic analysis of the gasifier-based silk reeling oven operating with a commercial outlook has been carried out in this chapter. The sensitivity analysis under different capital cost is also carried out. For this purpose, detailed cost estimate of the final Mark '4' model is made based on the manufacturers inputs. The benefits like fuelwood saving, silk yield improvement (renditta), and cocoon processing rate from the gasifier-based silk reeling oven were considered on the basis of field data collected during comparative performance testing of gasifier-based systems in Ramanagaram. However, the benefits like silk quality improvement is quantified based on the market appraisal of the silk yarn produced on the gasifier system.

The benefits like environment improvement is not quantified therefore not considered in the economic analysis.

4.1 Cost estimates of the gasifier-based silk reeling oven

The details of materials and approximate estimated cost of the various components/sub-assembly based on manufacture input is shown in Table 11.

Table 11. Gasifier-based silk reeling oven Mark '4' for silk industries

Cooking oven (A)	Amount (Rs)
MS Angle	6000
SS plate	15000
SS tube	7500
MS pipe	1000
Valves	1500
Insulation	1000
Fan 50 m^3/h at 150 mm gauge	1500
Copper vessels 4 nos	1500
Sub total A	35000
Gasifier (B)	
MS Fabrication	7500
GI fitting	1000
Castable	1500
Sub total B	10000
Grant total (A + B)	**45000**

4.2 Assumptions

The economic analysis of the gasifier-based oven is made based on the field testing of units at Ramanagaram. However, there are few important assumptions made in this economic analysis based on the field experience which are listed below.

1.	Unit operation	:	300 days/yr
2.	Cocoon processing rate	:	100 kg/day
3.	Cost of firewood	:	1 Rs/kg
4.	Cost of electricity	:	1.50 Rs/kWh
5.	Silk yarn price	:	1300 Rs/kg
6.	Fuel cutting cost (For operation of gasifier-based system)	:	150 Rs/ton
7.	Premium due to improved silk yarn quality	:	20 Rs/kg
8.	Interest on loan	:	20%

4.3 Field data considered for economic analysis

In the present analysis, following data based on field testing of gasifier system at Ramanagaram have been considered.

1.	Specific fuel consumption: convention oven	:	2.29 kg/kg cocoon
2.	Specific fuel consumption: gasifier oven	:	0.94 kg/kg cocoon
3.	Improvement in silk yield with gasifier oven (average for 82 data points)	:	350 g/100 kg cocoon

4.4 Benefits (per day) of gasifier oven over conventional oven

The benefits for shifting from conventional oven to gasifier system are as follows:

Conventional oven

1.	Fuelwood consumption per day (229 kg @ 1.00)	:	Rs 229

Gasifier oven

2.	Fuelwood consumption per day (94 kg @ 1.00)	:	Rs 94
3.	Saving on fuel (135 kg firewood)(1-2)	:	Rs 135
4.	Silk yield improvement (0.350 kg*1300 Rs/kg)	:	Rs 455
5.	Improvement in quality (Rs/kg 20*10.35 kg)	:	Rs 207
6.	Total (3+4+5)	:	Rs 797
7.	Additional running cost (electricity & diesel) per day	:	Rs 30
8.	Addition fuelwood cutting cost per day (94 kg*0.15)	:	Rs 15
9.	Actual/net benefits (6-7-8)	:	Rs 752

4.5 Sensitivity analysis for different cases

The present Mark '4' gasifier-based system cost breakup is as follows:

1.	Production cost including transport (Rs)	:	45,000
2.	Packaging, insurance and transportation cost (Rs)	:	5,000
3.	Installation, marketing and after sales services (Rs)	:	15,000
4.	Total investment for gasifier-based system (1+2+3) (Rs)	:	65,000

However, industrial prototype (with additional features) can cost about 25% more. But later, due to mass production, the product cost may come down. Therefore, present sensitivity analysis of the economic model of gasifier-based system is carried out considering three different capital cost of the system.

Case I: Considering the present cost of the system

Case II: Considering the cost of industrial prototype (with additional features)

Case III: Considering the mass production cost of the industrial prototype

4.5.1 Source of finance

For the purpose of economic analysis the means of finance for the total system are as follows

1.	User contribution	:	50% of the total cost
2.	Term loan	:	50% of the total cost

Under each case the payback of total investment, break-even and internal rate of return is calculated on three different scenarios. First scenario is considering only wood saving benefit. Second scenario considering both wood saving and silk yarn yield improvement. Third scenario considering wood saving, silk yarn yield saving and silk yarn quality improvement saving.

4.5.2 Case I: Considering the present cost of the system

Investment

The capital cost of the system	:	Rs 65,000

Annual additional cost of gasifier

Interest on investment (20%)	:	Rs 6,500
Maintenance	:	Rs 1,500

Contingency	:	Rs 500
Total additional cost of gasifier/year	:	Rs 8,500

Based on this cost, payback, break-even and internal rate of return is calculated and given in Table 12. It can be seen from the table that return on investment comes to 28% with wood saving only and 330% considering all the benefits.

Table 12. Payback, break-even and internal rate of return under different scenarios for case I

Item	Wood only	Wood + silk	Wood + silk + quality
Payback (no. of days)	1055	126	91
Break-even (no. of days)	95	16	12
Return on investment (%)	28	238	330

4.5.3 Case II: Considering the cost of industrial prototype (with additional features)

Investment

The capital cost of the system	:	Rs 80,000

Annual additional cost of gasifier

Interest on investment (20%)	:	Rs 8,000
Maintenance	:	Rs 1,500
Contingency	:	Rs 500
Total additional cost of gasifier/year	:	Rs 10,000

The simple payback, break-even and internal rate of return on investment is calculated and given in Table 13. It can be seen from the table that internal rate of return is only 21% with wood saving only and 266% with considering all the saving.

Table 13. Payback, break-even and internal rate of return under different scenarios for case II

Item	Wood only	Wood + silk	Wood + silk + quality
Payback (no. of days)	1413	156	113
Break-even (no. of days)	112	18	14
Return on investment (%)	21	191	266

4.5.4 Case III: Considering the mass production cost of the industrial prototype

Investment

The capital cost of the system	:	Rs 75,000

Annual additional cost of gasifier

Interest on investment (20%)	:	Rs 7,500
Maintenance	:	Rs 1,500
Contingency	:	Rs 500
Total additional cost of gasifier/year	:	Rs 9,500

Based on this simple payback, break-even and internal rate of return on investment is calculated and given in Table 14. It can be seen from the table that based on fuelwood saving only the internal rate of return comes 23%. However, considering all the benefits, internal rate of return comes to 329% and payback on investment comes to only 105 days.

Table 14. Payback, break-even and internal rate of return under different scenarios for case III

Item	Wood only	Wood + silk	Wood + silk + quality
Payback (no. of days)	1285	146	105
Break-even (no. of days)	105	18	13
Return on investment (%)	23	205	329

The summary of internal rate of return on investment, break-even and payback period for all the three different cases under three different scenarios is given in Table 15.

Table 15. Summary of payback, break-even and internal rate of return for all three cases under different scenarios

Item	Case I			Case II			Case III		
	Wood only	Wood + silk	Wood + silk + quality	Wood only	Wood + silk	Wood + silk + quality	Wood only	Wood + silk	Wood + silk + quality
Payback period (no of days)	1055	126	91	1413	156	113	1285	146	105
Break-even (no of days)	95	16	12	112	18	14	105	18	13
Return on investment	28	238	330	21	191	266	23	205	329

CHAPTER 5

Development of gasifier-based silk dyeing system

In the process of making finished silk fabric from cocoon energy input is required at various stages. Major thermal energy input is required in the processes of stifling and cooking cocoons as well as dyeing of silk yarn and fabric. Therefore, after successful development of gasifier based silk reeling oven it was decided to expand gasifier application to dyeing industry for improving its energy efficiency.

Figure 8 gives the flow chart depicting various processes used in dyeing industry. The yarn dyeing units are generally operated in large scale and are generally installed in a congested manner leaving very little space for further modification as well as for installation of a gasifier based system. However, the fabric dyeing units are of medium scale having sufficient space so as to accommodate the gasifier based system. There are large number of fabric dyeing units giving potential for large scale dissemination of developed technology after completion of its development process. Keeping these points in view, it was decided to develop gasifier system suitable for fabric dyeing unit.

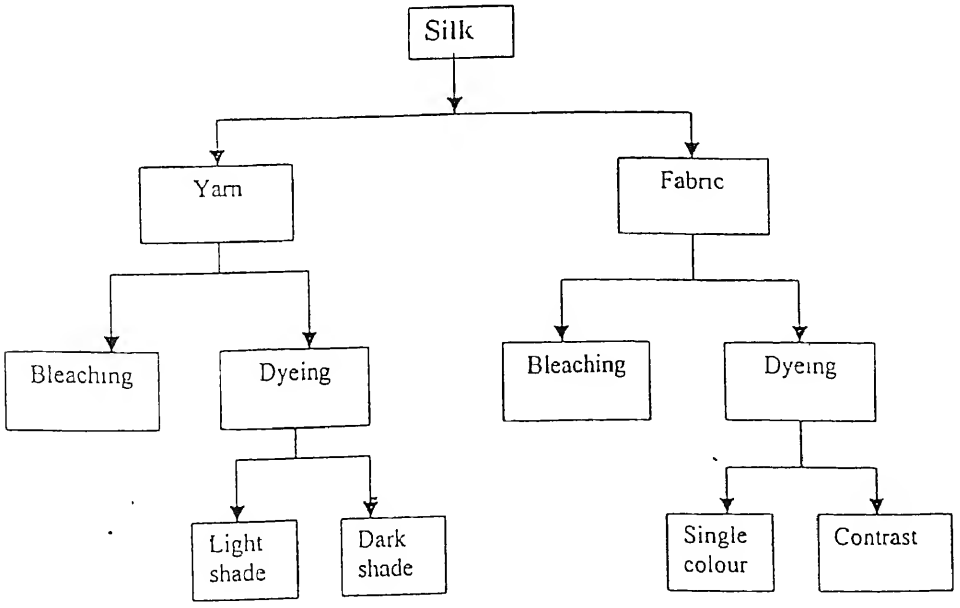


Figure 8. Various processes in dyeing industry

5.1 Survey of the different dyeing clusters

In order to design a gasifier based dyeing unit, a visit was made to several dyeing clusters in southern India. The main objective of the visit was to study the dyeing processes in detail and collect information on present energy consumption pattern and to understand the process heat utilization of the yarn/fabric dyeing industries so as to arrive at necessary design parameters for a gasifier based dyeing unit. For this purpose three different dyeing clusters were visited viz. Bangalore, Kanchivaram and Tirupur. The main observations are:

(i) the process and duration of dyeing varies from cluster to cluster,

(ii) different clusters maintains different temperatures in the dyeing bath,

(iii) the used water is thrown at end of the day while closing down the unit,

(iv) all the units operate in single shift only, working hours are increased some time depending on the work load,

(v) always a pair of dyeing vessel are used in every unit, one for bleaching and the other one for dyeing,

(vi) bleaching vessel also operates at the same power as that of the dyeing vessel,

(vii) clusters like Kanchivaram focuses on mostly yarn dyeing whereas cluster like Bangalore focuses on both yarn dyeing as well as fabric dyeing

Details of the dyeing units covered under the survey are given in Table 16. A summary of the survey data giving specific fuel consumption observed in various units for different fuel options is given in Table 17.

During the survey to different dyeing clusters, users expressed their willingness for trial of the gasifier system by providing space for installation and using the system for dyeing application. The "Pallavi Process", a fabric dyeing unit at Padmanabhanagar, Bangalore is selected for the installation and testing of gasifier-based dyeing system.

Table 16. Details of dyeing units surveyed

Sr no.	Dyeing material	Fuel	Fuel consumption	Place	Owner name	Capacity		Vessel dimension (in cm)	Volume of water (l)	Operating temp (°C)	Useful power (kW)	S.F.C.
						kg/batch	kg/day					
1	SY	K	20 lit	Cubbanpet	Mani	4	20	ϕ=65, h=27	56	95.8	9	1 l/kg
2	SY	FW	500 kg in total	Cubbanpet	Mani	15	50	120×83×75	647	98	72	5 kg/kg
3	SY	FW	500 kg in total	Cubbanpet	Mani	15	50	120×80×75	647	98	72	5 kg/kg
4	SY	D	-	Cubbanpet	Palani	10	30	75×60×60	225	96	25	5 kg/kg
5	SY	FW	60	Cubbanpet	Palani	20	60	122×63×57	361	98	40	-
6	SY	D	30	Cubbanpet	Palani	30	90	150×75×60	562	93	63	1 l/kg
7	SF	FW	250	Padmanabhanagar	N Subramanian	0.3	30 to 40	ϕ 75, h=51	160	97	15	6-8 kg/kg
8	SF	FW	250	Padmanabhanagar	N Subramanian	0.3	30 to 40	ϕ 75, h=51	160	97	15	6-8 kg/kg
9	SF	FW	250	Padmanabhanagar	N Subramanian	0.3	30 to 40	ϕ 75, h=51	160	89	15	6-8 kg/kg
10	SF	FW	250	Padmanabhanagar	N Subramanian	0.3	30 to 40	ϕ 75, h=51	160	90	15	6-8 kg/kg
11	SF	FW	150	Kanchivaram	V P Ramachandran	2	30	ϕ 47, h=45	24	99.3	4	5 kg/kg
12	SF	FW	150	Kanchivaram	V P Ramachandran	2	30	ϕ 47, h=45	24	98.5	4	5 kg/kg
13	SF	FW	150	Kanchivaram	Varadarajan	2	25–30	ϕ 47, h=45	23	99.0	4	5 kg/kg
14	SF	FW	150	Kanchivaram	Varadarajan	2	25–30	ϕ 47, h=45	23	99.2	4	5 kg/kg
15	SF	FW	175	Kanchivaram	Nagarajan	2	24 to 25	ϕ 45, h=35	24	99.3	4	7 kg/kg
16	SF	FW	175	Kanchivaram	Nagarajan	2	24 to 25	ϕ 45, h=35	24	98.1	4	7 kg/kg
17	CY	FW	1500	Tirupur	Jagannathan	300	300	600×400×120	4000	70 to 80	-	2 kg/kg
18	CY	FW	1500	Tirupur	Balasubramanian	300	300	600×400×120	4000	70 to 80	-	2 kg/kg

SY = Silk yarn SF = Silk fabric CY = Cotton yarn
K = Kerosene in lit D = Diesel in lit. FW = Fuel wood in kg.
SFC = Specific fuel consumption

Table 17. Specific fuel consumption in dyeing with various fuel options

Sr. no.	Fuel used	Specific fuel consumption (kg/kg of yarn dyed)
1.	Wood-open firing (large scale)	5 kg/kg
2.	Wood-open firing (small scale)	7 kg/kg
3.	Wood through boiler	2 kg/kg
4.	Kerosene	1 l/kg
5.	Diesel	1 l/kg

5.2 Detailed energy audit of selected dyeing units

A detailed energy audit was carried out in two silk dyeing units in Bangalore namely Shilpa Dye Print and Pallavi Process. The major objective of the experiments were to get the process operating parameters so as to arrive at initial and running power of the existing dyeing oven. The data collected during test runs includes:

1. Wood consumption
2. Time activity during complete day
3. Water addition and removal (quantity and temperature) used during process.
4. Flue gas analysis (% O_2) and flue gas temperature) every 15 minutes throughout the operation.
5. Fabric (by weight) dyed during the day.
6. Amount of water carried by fabric (for few random batches).
7. Amount of water drained at the end of the batch.
8. Amount of water evaporated during the day (by water balance).
9. Water boiling test at the start of the batch (for initial power measurement).
10. Water boiling test during the batches (for running power).

The summary of the detailed energy audit is given in Table 18. During the energy audit dialogues were initiated for installation of gasifier-based unit. The possibility of testing the unit and further improvement of the system to suit the field condition.

Table 18. Summary of the detailed energy audit carried out in the dyeing units

Sr. No.	Date	Name of unit	Type of oven	Time of operation	Fuel consumed (kg)	Fabric yarn dyed (kg)	Initial power (kW_{th})	Running power (kW_{th})	Various heat streams (% of input heat)				
									Drain	Fabric	Water evaporation	Flue gas	Structure loss
1	23/07/98	Shilpa	Fabric	9.00-17 00	Wood – 39 Twigs – 16 6 Kerosene – 650 ml	24.2	4.15	1.0 to 5 45	3 35	1.68	21.0	52.0	0.7
2	25/07/98	Pallavi	Fabric	6.20-12 15	Wood – 71.9 Twigs – 51 1	26 92	12 2	12 4	5.1	6.36	9.1	55.2	1.2
3.	27/07/98	Pallavi	Fabric	6.56-13.02	Wood – 91 6 Twigs – 19.6	53 94	12 48	-	2 9	2.6	11.4	59.0	1.1
4	28/07/98	Shilpa	Silk yarn	8 45-13.00	Kerosene-12 7 lit	76 6 (wet)	15 98	3 58	13.6	3.7	1.0	40.0	0.65
5.	29/07/98	Shilpa	Fabric	9 05-17 14	Wood – 31.6 Twigs – 9.4	30.56	5.32	2.2 to 6.98	3.5	3.85	17.1	55.0	0.67

5.3 Design development of laboratory prototype

Development work was initiated with developing a single vessel dyeing unit. The basic parameters for the burner configuration, like distance from the vessel to the burner and the vessel supporting, side wall enclosures etc. was finalized through several trial runs. Similar to Mark `4' silk reeling unit, here also gas bubbling unit was avoided and instead of that hot gas was taken from gasifier to burner through insulated rectangular duct. Glass wool insulated duct help to retain high temperature of gas preventing any condensation of tar inside the duct and low velocity due to larger duct cross sectional area helps in reducing gas flow velocity and thereby allowing settling of heavy dust particulates present in the gas. The pressure drop across the duct is very low because of large cross sectional area. This helps in operating the system with a low capacity blower.

In order to monitor the thermal performance of the unit several water boiling tests were conducted. Water temperature rise profile during one typical water boiling test is given in Figure 9. It can be observed that the system operates with 26 kW_{th} output with good (44%) thermal efficiency. The average fuel wood consumption rate of 11 kg/hr was observed during the test run and it took 15 minutes to boil the water in the vessel.

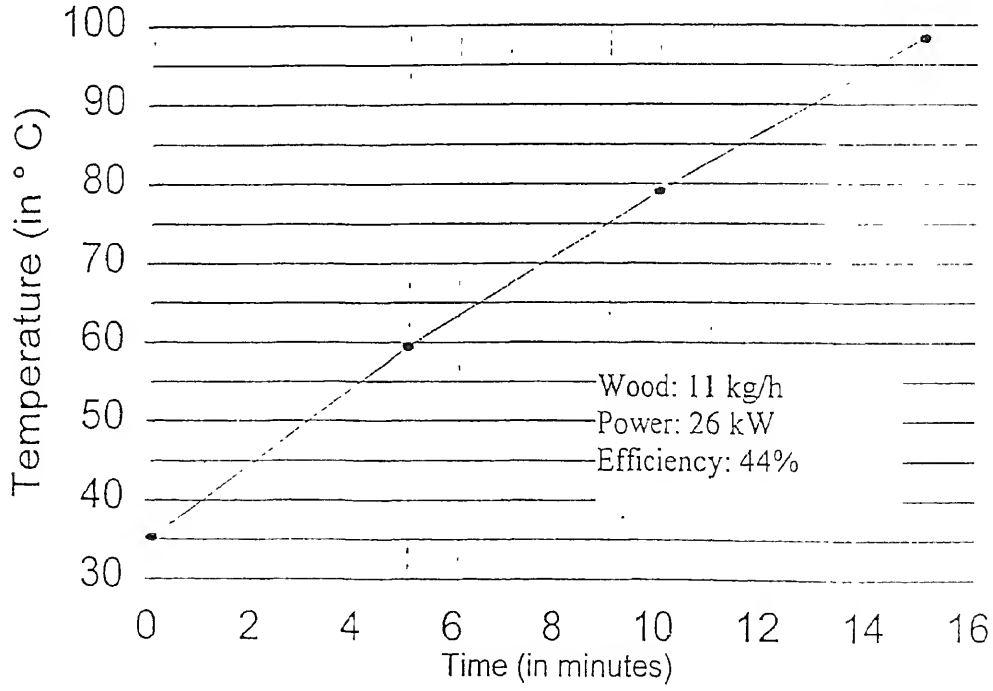


Figure 9. Water boiling test on single vessel gasifier-based laboratory dyeing prototype

Later on based on field visit observations, it was decided to develop laboratory prototype dyeing system having two water bath or vessels The drawing of the first laboratory prototype is prepared and is given in Figure 10.

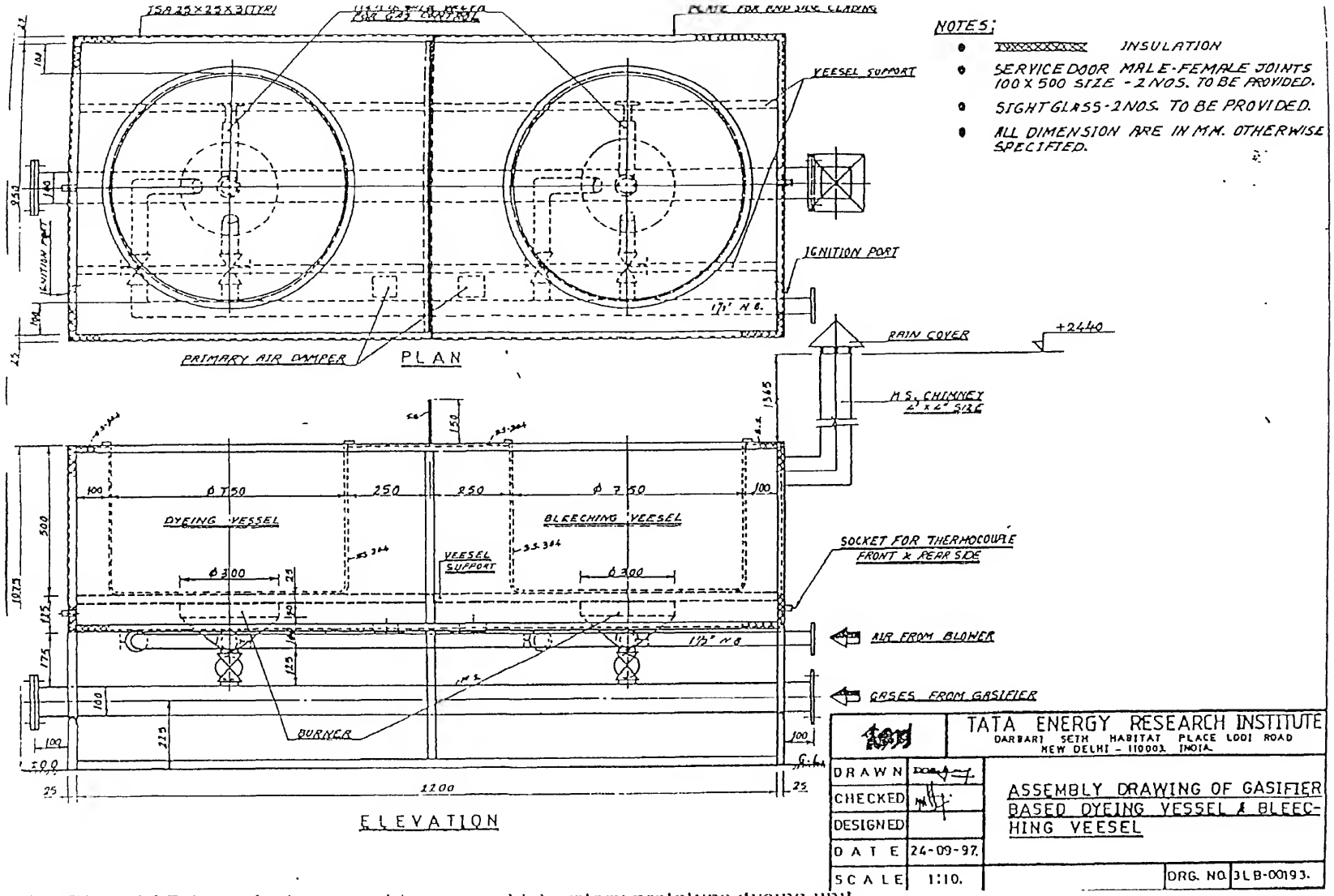


Figure 10. Schematic diagram of twin vessel laboratory prototype dyeing unit

The prototype was installed at Gual Pahari and trial runs were conducted with single burner. In order to make the system manufacturable in the workshop it was made with entire metallic structure. The dyeing unit was supported by 2 inch MS angle and covered and the vessel was covered with 2 mm MS sheet. The top portion of the dyeing unit was covered with SS 304 sheet in order to avoid problem of rusting due to spillage of water over it during dyeing operation. However the overall working height of the unit worked out to be higher. The detail water boiling test curve for both the vessels with single burner operation is shown in Figure 11. The test results indicate an average over all efficiency of the order of 42% including 12% heat recovered from flue gas by the second vessel. The useful power levels of the main vessel above the burner works out to 18 kW_{th} while that of waste heat recovery vessel works out to 7 kW_{th}.

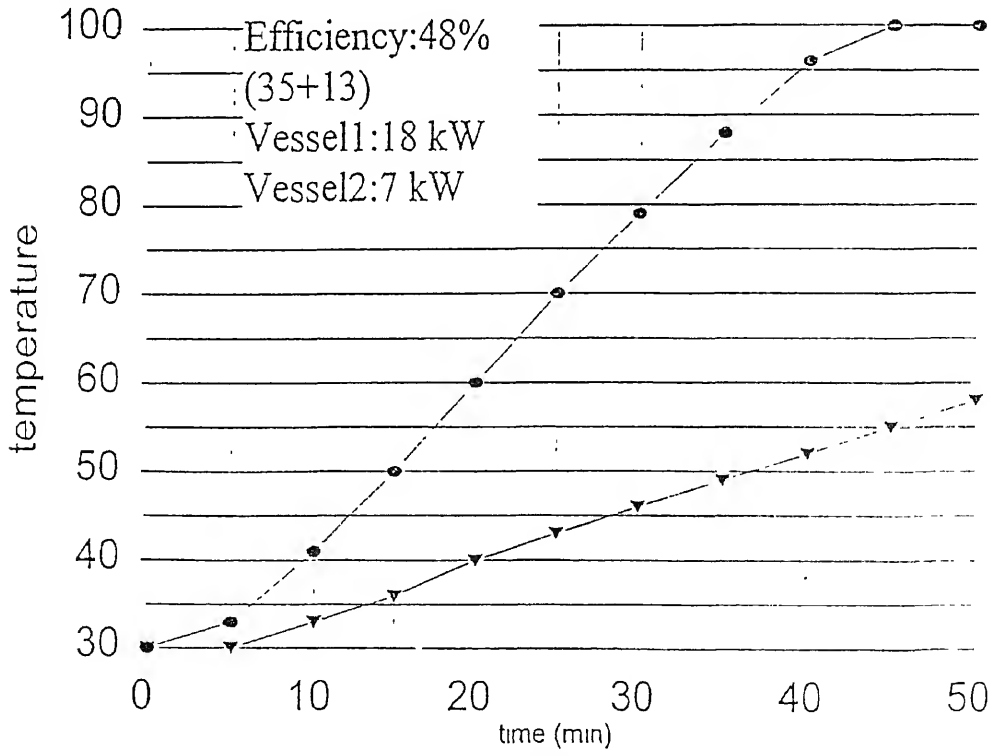


Figure 11. Water boiling test on twin vessel gasifier based laboratory dyeing prototype using single burner

5.4 Fabrication and installation of gasifier-based field dyeing unit

In designing the field prototype unit the oven portion of the dyeing unit was made with civil construction. This decision was taken mainly due to very high surface temperatures in the metallic oven structure and also it was felt that transportation of too big and heavy structure will be difficult. A RCC (Reinforced Cement Concrete) slab of 2 inch thick is supported by six pillars and used as the base of the oven. Vessels are supported on MS C-channels. The channels are placed in such way that the load is distributed on the base pillars instead of the side wall. Side wall is constructed with 230 mm thickness. The firebricks are used in the inner portion of the oven which are exposed to a high temperature flame. A layer of normal clay bricks is used for the wall on the outer side of the dyeing oven.

The top of the dyeing oven is lined with firebrick tiles, covered with a layer of ferrocement concrete. The entire oven is plastered with 1:5 cement mortar to have a fine finish and to provide a neat and clean surface. The top surface of the vessel is tilted towards opposite side of the user to avoid any hot water spillage on the operator while doing the dyeing job.

Figure 12 shows the photograph of the dyeing unit installed at Pallavi Process, Bangalore. The detailed schematic drawing of the field prototype unit alongwith dimensions is given in the Figure 13.

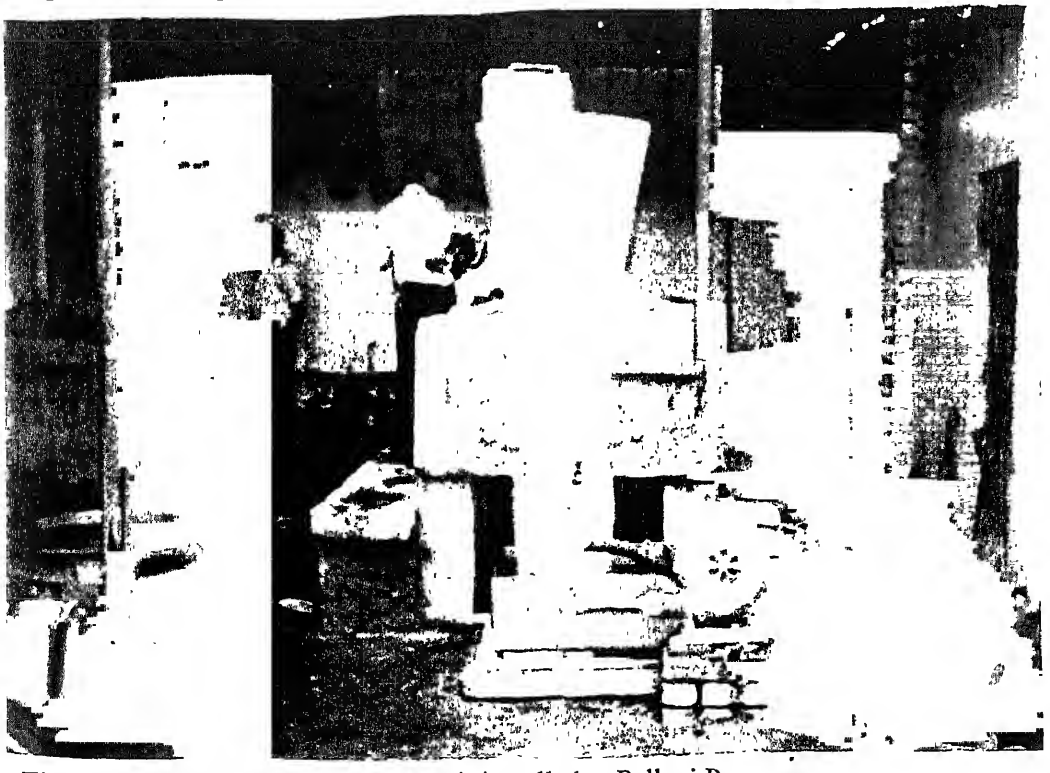
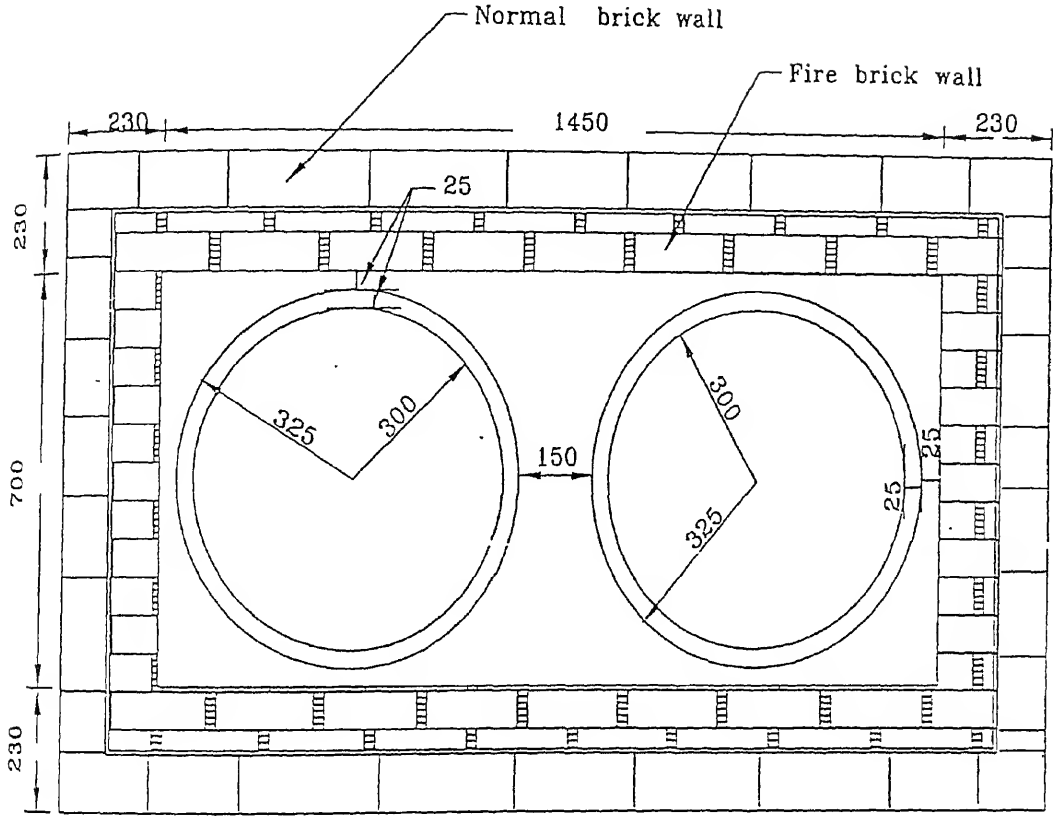


Figure 12. Gasifier based dyeing unit installed at Pallavi Process



Dyeing oven Plan

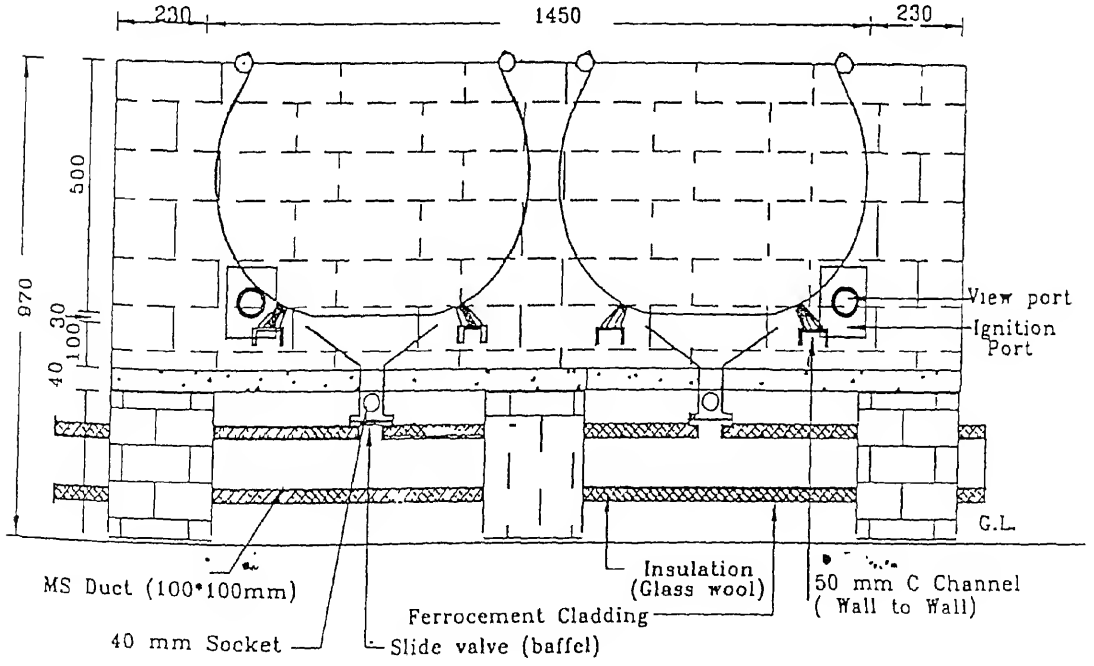


Figure 13. Schematic diagram of field prototype dyeing unit installed at Pallavi Process

Water boiling test is conducted for analyzing the system performance and working power and the efficiency of the system. The system performance curve obtained during the water boiling test is given in the Figure 14. It can be observed that the useful power of the main dyeing vessel is 17 kW_{th} and the overall operating thermal efficiency of the system is about 46% which is more than double that of the conventional dyeing oven. This is a clear indication for saving a minimum of 50% fuel in comparing with the conventional dyeing oven.

Water boiling test is conducted for analyzing the system performance and working power and the energy of the system.

Detailed comparative test runs in order to assess and quantify benefits of the gasifier based dyeing unit over traditional oven are planned for the next phase.

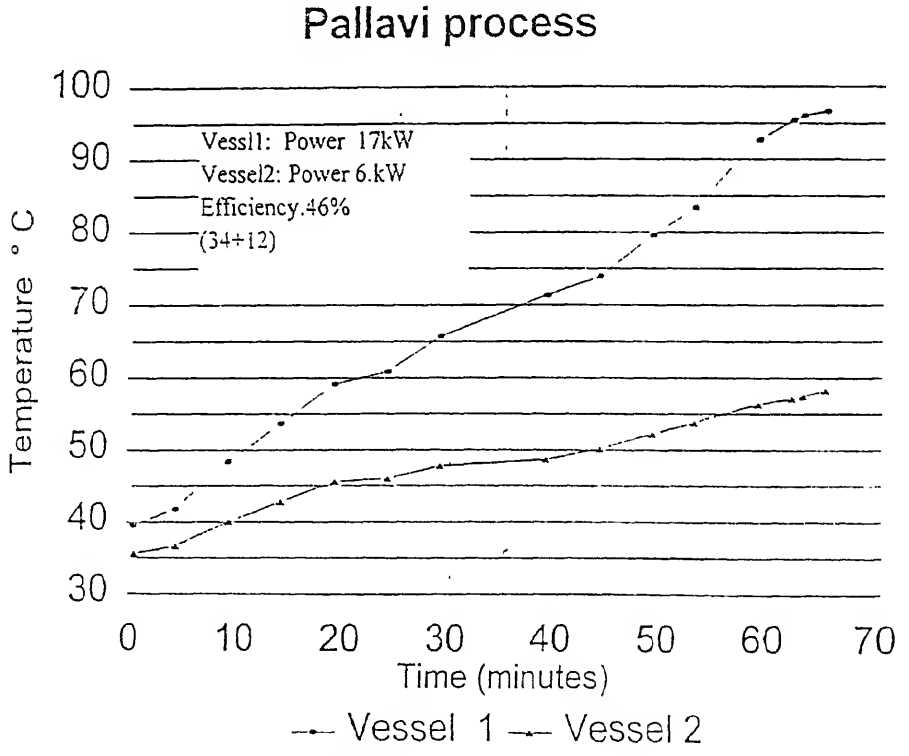


Figure 14. Performance curve for field prototype dyeing unit

CHAPTER 6

Efforts towards market development of gasifier systems

In order to study the market potential and acceptability of the wood gasifiers in silk industry and to penetrate the gasifier system to other market. Four studies were conducted, first study on cluster level survey of Siddlaghatta cottage basin to identify the number of silk reeling ovens, geographical spread of unit, the past trend of cocoons and silk market, number of cottage basin, average size of units. A second study on survey of market potential of gasifier-based silk reeling ovens is assigned to Greenergy Systems Bangalore to obtain information on the economic conditions of the market, build up a marketing strategy based on the market, locate key people among the reelers who will aid us in marketing, to develop integrated methodology for supply, erection and commissioning, after sales service, sourcing of assured cut wood supply to customers etc. and to suggest the most pragmatic and effective approach for commercialization of the product and for establishing a distribution and service to the customers. The third study related to study on development of quality in users services covering the complete spectrum of marketing, manufacture, erection, commissioning, training after commissioning services. This study is carried out by Greenergy System Bangalore. The fourth study on developing mechanism and procedure for technology transfer and dealing other legal issues related to the marketing of gasifier-based system covering all legal issues associate with the commercialization of these systems is carried out by Dr Y S Rajan of CII. The chapter also discussed efforts towards further improvement in design of gasifier system.

6.1 Developing market strategies for gasifier-based systems

In earlier phase of the project- a study was carried out by I J Raju and Associates on "Issues related to commercialization of gasifier-based silk reeling systems" and submitted the report to SDC. Unfortunately, Dr I J Raju passed away early February 1997. Further inputs were not received on the subject.

Meanwhile, Mr Greg Wishart, Management Consultant from UK was contacted and visited the gasifier-based silk reeling sites in May 1997 during his trip to India. Further, TERI and Mr Wishart made their respective presentations on issues related to commercialization of gasifier-based systems at SDC Delhi in the month of September 1997. Later, based on the discussions, TERI prepared a set of ToRs for consultants namely Mr Wishart, Mr Pierre Jaboyedoff and Dr Y S Rajan in order to start the preparatory phase of test marketing. Subsequently, the ToRs were modified based on the discussions with SDC team. The final ToRs of Mr Greg Wishart and Mr Pierre Jaboyedoff are enclosed as an Annexure 2.

Dr P Chakravarty, who spent several years in a commercial gasifier manufacturing firm, has joined the TERI gasifier team. He will be specifically looking after the marketing aspects of gasifier-based system. A small marketing team was formed, within the project group, consisting of Dr V V N Kishore, Dr P Chakravarty, Mr Sunil Dhingra from TERI and Ms Ariane Waldvogel from SDC to look into the commercialization aspects of the gasifier-based systems.

The team started interaction through regular group meetings. In these meetings, brainstorming on different manufacturing and marketing ideas/models were discussed in order to evolve most appropriate methodology for marketing these systems. The first effort towards in this direction is to review all potential manufacturers and marketing organization already approached.

6.1.1 Preliminary review of potential manufacturers

It was further decided to select proper manufacture and marketing organization who could be associated with the team for the next phase of test marketing activities. In this regards a detail questionnaire was prepared (enclosed as Annexure 3) and sent to all the potential manufacturers and marketing organizations. In addition, the team made specific visit to different potential manufacturers/marketing organizations located in Bangalore and Coimbatore on 21 to 25 April 1998 to assess their technical, marketing and financial capability. Similar visit was made to manufacturer located in Delhi on 14 May 1998. The team made visit to Yamunanagar manufacturer on 20 May 1998. Based on this preliminary review the team short listed a marketing organization based in Bangalore (Greenergy System) and manufacturer (Urjex Boiler) based in Meerut for test marketing phase. Further inputs in this regard will come from mission consisting of Mr Greg Wishart and Mr Pierre Jaboyedoff. The detail report of these visits is given as an Annexure 4. Based on this review the first draft of basic framework for the marketing and commercial model of gasifier-based system is prepared (see Annexure 5).

A draft license agreement between TERI and manufacturer is prepared through M/s Davar & Company regarding the transfer of technology for large scale production. The draft agreement is under discussion with SDC and other consultant for finalization. A copy of the draft licencee agreement is given as an Annexure 6.

6.2 Cluster level survey of other reeling area such as Siddlaghatta, Vijaypura etc.

A cluster level study for Ramanagaram cluster was carried out in last phase to obtain the average capacity of reeling oven in that cluster. It was felt necessary to take up similar studies in areas other than Ramanagaram so as to consolidate the base data to design similiar system for these clusters. A study title "Profile of an average cottage basin reeling unit at Siddlaghatta" was given to Mr T S Nagaraj. The objective of this study was to facilitate information with proper quantification about the various processing inputs used in an average cottage basin reeling unit. This is expected to assist designing of an effective and affordable gasifier system suitable for cottage basin reeling units of Siddlaghatta .

Siddlaghatta (SDL) is the most popular reeling center in Karnataka. The trade prefers the silk produced at SDL on account of certain special characteristics possessed by it, like stiffness, lower sericin content etc. On account of these specialties, SDL silk commands a better price in the market. SDL is a township with a population of 25,157 (1991 Census) in the town proper. The major occupations of people of SDL are agriculture and sericulture.

There is a cocoon market at SDL, which has an average monthly transaction of 700 tons per month valued at about Rs 765 lakhs, at an average price of Rs 105 per kg. There are other wings of sericulture department in SDL like the silk exchange, enforcement, grainage etc. A branch of Karnataka Silk Marketing Board is also functioning here. Apart from these, branches of nationalised banks like Canara Bank, State Bank of Mysore etc. are established there.Since the silk yarn of SDL fetches a premium price, normally better quality cocoons are brought to SDL cocoon market in the hope of getting a higher price. About 9000 acres of land in SDL are under mulberry.

There are 2335 silk reelers according to the number of licenses issued. However, only about 562 licenses have been renewed.The reeling activity in SDL differs from that at either Ramanagaram or Kollegal. In SDL, silk is directly reeled on to a larger reel, without going through the process of re-reeling. This system of reeling is referred to as Italian system. Likewise, the process of "Cooking of cocoons" also differs. The arrangement of cooking vessels in relation to each basin is different in the cottage basin units at SDL.

Based on the study, it was found that reeling activity in Siddlaghatta is different from that at Ramanagaram in the process flow, layout of the unit and machinery. Re-reeling process is excluded from the process flow.

This difference in the style of operation together with better quality of reeling water ensures production of comparatively better quality of silk.The size of an average reeling unit is much smaller. Generally, cocoon-cooking oven is used for stifling of cocoons, at Siddlaghatta.

- Reelers with 4 to 6 basins can be considered as average reelers.
- An average reeling unit consumes about 100 kgs of firewood per day.
- A 4-basin unit used about 1000 to 1200 liters of water per shift of 8 working hours.
- An average reeling unit consumes 36 to 54 kgs of cocoons per day.
- The average renditta reported is between 9 and 10.
- The cocoon-cooking vessel used has the following dimensions
  - Diameter of top of the vessel = 310 mm
  - Diameter at the bottom = 300 mm
  - Height of the vessel = 380 mm

The final report will be given in supplementary volume.

6.3 Survey of market potential for gasifier-based silk reeling ovens

A study title 'survey of market potential for gasifier-based silk reeling ovens' was awarded to M/s Greenergy with following objectives:

The main objectives of the study are listed below.

- To obtain information on the economic conditions of the market
- To estimate likely sales volume
- To determine price acceptable by the customer for the product
- To build up a marketing strategy based on the market
- To ascertain whether external finance will be required for the market to afford these units.
- Locate key people among the reelers who will aid us in marketing
- Create awareness of these systems to the reelers and determine profile of prospective customers
- To develop integrated methodology for supply, erection and commissioning, after sales service, sourcing of assured cut wood supply to customers etc.
- To suggest the most pragmatic and effective approach for commercialization of the product and for establishing a distribution and service to the customers.

Greenergy Systems is a partnership firm established in 1996 for promoting use of non conventional energy sources. Focus is placed particularly in the area of renewable energy sources like biomass such as rice husk, groundnut shell etc. as practical sources of energy to be used with maximum efficiency and maximum pollution. Greenergy Systems has considerable experience in marketing, erection and commissioning and after sales service of engineering equipment like boiler, gasifier and power systems. The final report of the study will be provided in the supplementary volume.

6.4 Study on development of quality in users services

Further, to facilitate the wide spread use of this units the need was felt for an extensive study on development of quality in users services covering the complete spectrum of marketing, manufacture, erection, commissioning, training after commissioning services. In view of this TERI approached Greenergy Systems to undertake this study in view of their experience in similar fields i.e. process heating systems and gasifiers. The objective of the said study is as follow:

- Methodology for identification or potential manufacturers
- Management of marketing and sales
- Ensuring quality service and maintenance
- Collect information on what the potential alternate market for gasifier such as cooking, water heating, dyeing etc.
- To evaluate how gasifiers can be useful in saving energy and the cost benefit in various process industries.

This study entails extensive primary research for fixing various definitive processes in the activities of manufacturing, marketing, erection, commissioning, training and after commissioning service. The major outcome of the study is as follows;

1. There is a huge potential market for gasifiers and more importantly there exist a good need and want for this product.
2. The marketing strategy will be first to test market the product and create awareness through out the focussed target market. This will help in generating good number of prospective customers, which will assist during full scale commercialization of the product.

3. Specific marketing strategy will be to penetrate slowly but strategically into the market in terms of price payment flexibility and also utilise the presently existing satisfied customers to promote the product. The marketing efforts will be well complimented with development of effective and aggresive sales and after sales service teams.
4. Also, from this study report it can be concluded that there is also huge potential for gasifiers in other market segments such as hotels, dyeing industries etc., and plan to move strategically to different market segments phase by phase.

The final report will be given in supplementary volume.

6.5 Developing mechanism and procedure for technology transfer and dealing other legal issues related to the marketing of gasifier-based systen

In order to produce gasifier-based silk reeling systems through commercial supply chain, there is need for induction of few other partners and develop supply chain. This includes selection of manufacturer, financial institution or firm, marketing dealer and agents network, service and maintenance team etc. Therefore, it is important to develop a mechanism and dea all legal issues associated with the commercialization of these systems. The broad set of objectives which need to answer are:

- Agreement between SDC-TERI regarding the sharing of technology fee and royalty
- Preparation and finalization of licence agreement between TERI and potential manufacturers and marketing organisation
- Framework for preparing `technology package' for potential manufacturer.
- Filing of brand name, logo etc.

For this purpose a consultancy contract is given to Mr Y S Rajan of CII . The final report is awaited and same will be provided in supplimentary volume.

6.6 Filing of patent

A provisional patent application title "A cooking/heat recovery device for the cooking of cocoons" is filed under the patents Act 1970 in India by TERI on 17 June 1997 through patent attorney M/s L S Davar and Company. The patent application number 1627/DEL/97 was allotted by the patent office. The provisional patent was filed in place of final patent in order to facilitate finalization of the gasifier system design after field testing. After successfully field testing the unit in Ramanagaram, the final detailed specifications of the

system was filed with complete drawing on 9 June 1998. A copy of the filed patent specification is given as an Annexure 7.

6.7 Design inputs on Mark '4' gasifier system (IIT Bombay)

Prof. Vijay Bapat, IDC (Industrial Design Centre), IIT Bombay, has visited Ramanagaram in the earlier phase to study the gasifier-based silk reeling oven. In the current phase, after commissioning of the two Mark '4' systems in Ramanagaram, a consultancy contract with IDC, was finalized with the following objectives:

- to study working of Mark '4' system in detail, from the point of manufacture, transport installation use and maintenance.
- to work out remedial solution to various problems identified.
- to work out engineering drawings and to fabricate details of scale mock-up model.

Prof. Bapat visited the Mark '4' sites on 18th and 19th of April 1998. Unfortunately, both the reeling units of Mr Pasha's and Mr Babu's were non-operational on that day due to very high market price of cocoons. A detailed documentation of various stages of operation was done through photography and video recording.

Mark '4' model has been working without any major problems for the last few months at both of these reeling units. Most of the problems identified and recorded in the first and second reports on gasifier have already been take care of and major maintenance problems associated with Mark '3' are reduced to minimum.

In first part of this report a few problems related to man-machine relationship area and construction details are presented in photo documentation format. The detailed report of Prof. Bapat will be enclosed in the supplementary volume.

Prof. Bapat also visited the silk dyeing units near Bangalore during his visit on 18th April 1998. Based on his visit a consultancy contract was finalized with the following objectives:

- to give two or three ideas of fabric dyeing unit taking into consideration the human factor.
- to develop a mock-up model at a suitable scale giving due consideration for manufacturing aspects

Prof. Bapat visited the gasifier-based dyeing installation on 25th September 1998, final report on the above subject is still awaited and will be provided in the supplementary volume.

CHAPTER 7

Review workshop on "Gasifier-based systems for silk industry"

The purpose of the workshop was to review the progress of the project in this phase and plan the activities for the future. Another related objective was to collect opinion from reelers, dyers, manufacturers consultants, silk expert, marketing experts and experts from financial institutions on issues related to marketing of the product developed for silk reeling system. The one-day review workshop was organized at Hotel Rama, Bangalore on 24 September 1998.

The participants included four SDC officials, two SERI 2000 officials/advisors, three reelers, two manufacturers, one dyer, one representative each from marketing agency and financial institution, and two consultants. The delegates were welcomed by Mr H V Dayal, Dean, Bangalore Regional Centre of TERI and Mr Charles Geiger, SDC, Bangalore.

Dr Heierli, SDC, New Delhi provided the introductory address and Ms H R Girija, SDC, Bangalore, gave overview of the project. She explained the developmental stages of gasifier-based reeling system from Mark '2' in Hindupur to present Mark '4' at Ramanagaram.

Session 2 focused on "Presentation on development of gasifier-based systems", which was chaired by Mr Mahadevappa. Mr Sunil Dhingra presented "Summary of project findings" of TERI team at Ramanagaram reeling units. He said that the reelers accepted the new cooking bath concept in Mark '4' system. Wood consumption reduced further in Mark '4' system to 0.85 kg wood/kg of cocoon processed which was 1.3 in Mark '0' to Mark '2'. In Mark '3' it was 1.15 and in the conventional oven it is 2.3. Increase in silk yield by 350 gm/100 kg cocoons was achieved (increase in silk yield was 250 g/100 kg cocoons in Mark '3' systems) with Mark '4' system.

The estimated benefits from gasifier over conventional oven are about Rs 820 per day after deducting the cost on electricity and diesel spent to operate the blower. He said that the gasifier seems to payback on total investment in only about 61 working days considering all the benefits of saving in wood, increase in silk yield, improvement in quality and increased productivity. The payback period will be about 435 working days if only wood saving is considered.

Mr Dhingra mentioned about other developments in the project on market development, patent, technology transfer, and marketing model for test marketing phase. On the summary of Mark '4' test runs, he said that gasifiers have been operated (Pasha and Babu unit together) for about 200 days, logging about 1035 hours. In this time 9086 kg of cocoons

were processed producing 1064 kg of raw silk yarn. Regarding investment on gasifier he said that the additional investment is about Rs 50000 over the conventional system, cater to a 10 basin reeling unit (Rs 15,000 is the investment on conventional system). However, total additional annual cost involved with the gasifier system is about Rs 20,000.

The second presentation by Mr T S Nagaraja was on "Summary of silk quality test results". The salient points of his presentation are as follows:

- The special features of main vessel and support vessels in Mark '4' system creates partial pressure
- Volume of water contained in the main vessel is higher has implications on cocoon cooking
- At operating levels, Mark '4' system ensures nearly constant water level in the main and support vessels. Thus this requires less/no supervision on water management.
- Mark '4' system ensures almost a constant temperature of 92 ± 2 °C.

The combined effect of the above four features has resulted in several advantages:

(i) improved cocoon cooking;
(ii) improved reelability;
(iii) lower renditta;
(iv) automatic water and fuel management at the cooking stage;
(v) reduction in processing time; and
(vi) improved performance of yarn at silk yarn twisting stage.

Results of comparative test confirm the following advantages:

- Renditta has reduced by 0.4 (Pasha and Babu units together)
- Batch time has reduced by about half an hour
- Cocoon cooking rate increased by about 1.05 kg/hr
- Less winding breaks observed in gasifier-based systems
- Less breakage rate was observed on gasifier in single twist stage

On other parameters of average size, size deviation, maximum deviation, average cleanness, average neatness, average low neatness, tenacity, elongation, cohesion, gasifier system has scored better than conventional system in both Pasha and Babu units.

Based on his observations on various aspects of processing on Mark '4' gasifier system, which ultimately has implications on the quantity and quality of the silk, Mr Nagaraja made the following recommendations;

- Pressure in the main vessel is not measured so far. It would be advantageous to manipulate pressure with different qualities of cocoons.
- Preliminary tests indicate that there may be more sericin loss during cooking and reeling on Mark '4' system. This is an added advantage to the weaver and this may improve bargaining power of the reeler, over time. Analysis of this aspect is recommended.
- Water quality in the cooking vessel appears to be affected particularly in respect of electrical conductivity. Further tests in this direction are recommended.

The third presentation by Mr Raman was on "Technical progress on gasifier-based dyeing system". He said based on reference data from few dyeing units; a prototype system was developed at Gual Pahari, which was completely a fabricated structure in sheet metal. However, this was changed to civil construction (oven part) keeping in view of field conditions and cost. One system has been installed at Pallavi Processes (a fabric dyeing unit) in Padmanabhanagar, Bangalore in the first week of September 1998. The trial runs have shown satisfactory performance and a couple of batches of saree dyeing also has been satisfactorily completed.

The fourth presentation in this section by Prof. Vijay Bapat was on "Design recommendations". He appreciated the continuous efforts made in the development of Mark '4' by the TERI team. Prof. Bapat appreciated the incorporation of the feed back on the improvement of the system from the last workshop into this latest model Mark '4'. However, he felt that this model still gives a confused picture and could further be improved in the following aspect's (i) convenient positioning of all control valves and indicators; (ii) firmer support to gasifier reactor which also should act as a ladder and mounting base to blowers; (iii) modification of oven in such a way that water spilled over the top portion while processing does not seep into the insulation, (iv) modular approach of the system for easy transport, (v) avoid all sharp edges, protrusions etc.

Session 3 focussed on "Marketing of gasifier-based systems" was chaired by Mr Parthasarathy. Dr V V N Kishore made the first presentation of the session on "Summary of efforts towards commercialization". He said that the gasifier-based system for the reeling

unit is a new product. He pointed out that till now the efforts was on developing the product. He said that for a product to take up well in the market, efforts are required not only the product development but also on other important aspects of marketing, publicity, and financing. He quoted the example of popularizing of hotmail.com by Mr Sabeer Bhatia who said that 25% of funds and efforts are required in the development of the product and 75% for other aspects like marketing, publicity and financing mechanisms. Regarding market penetration of new products, Dr Kishore said that most of the products followed an S-curve, which typically shows low penetration in the initial years, which pick up well for substantial duration, and then saturation. Dr Kishore said that gasifier-based system for silk industry seems to be similar kind of product and is likely to take the same route.

Mr Mathew Philip of Greenergy systems made the presentation on "Market survey of gasifier-based silk reeling ovens". He said that they have conducted a survey on this and the feedback was encouraging. Reelers have shown interest in buying such a system (which saves fuel). He also said that one reeler from Channapatna has placed an order for two numbers of gasifier-based reeling ovens.

During the days deliberations other issues on manufacturing, copying, marketing and financing mechanism were discussed. The manufacturers felt that the manufacturing this system is not cumbersome, however testing and branding of the product need to be carried out to maintain quality. Participants felt that system could go with TERI brand and felt that each of the first few systems should be tested for quality at the premises of the manufacturer by TERI team or persons authorized by TERI.

Regarding copying, Mr Sudhir Chandra, (Managing Director, Chandarpur works) felt that since this is a low value product, and not so complicated to manufacture, copying is inevitable. However, he felt that there would be a residence time of about two years for the licensed manufacturing before copying takes place. Hence, he said that one should capitalize on that and make an impression to popularize the brand. Mr Balakrishana Arya (Proprietor, Aryan Industries) felt that though copying is possible, lots of customers come to established brands/manufacturers though their prices are higher. He said that this has been his experience with the manufacturing and marketing of reeling machinery.

Regarding marketing, reelers felt that this is a product worth investing in, however they felt that looking at the customer's profile, a financing mechanism might be needed for many reelers.

Finance experts said that the customers could approach financial institutions like Banks, KSFC for a loan on the system. Mr Arya said that it is routine that many reelers come to him with loan arrangement from KSFC to purchase reeling machinery, while he does not deal directly in getting loans for his clients. He said that similar model can be adopted with this product (gasifier system) as well.

The reelers during the days deliberation endorsed the benefits mentioned in the summary of project findings except realizing the price advantage due to improved quality. Additionally, they said that, the shade of silk yarn from gasifier system is more uniform which is perhaps advantageous in selling.

CHAPTER 8

Conclusions and recommendations

This phase of the project, sponsored by SDC, TERI had developed an industrial prototype (Mark '4') gasifier-based silk reeling oven system for cottage basin units. The unit was developed and tested under simulated field conditions at TERI's Gual Pahari campus. After successful completion of testing, two such systems were fabricated and installed at Pasha and Babu units at Ramanagaram in Karnataka for field testing-cum-demonstration. The major objective of the project was to comparative testing of the wood gasifier-based silk reeling system such as fuel saving, silk yield and quality improvement.

During comparative testing of the system under actual field conditions the data collected is quite encouraging. It has statistically proved that the system saves about 65% fuel compare with 50% saving with earlier model and also improves the silk yarn yield or renditta giving around 350 g more yarn through processing of 100 kg cocoon in a day. It was also observed that the labour productivity and working conditions are also improved due to consistent power and less smoky conditions. Improvement in silk yarn quality though observed and felt by reelers, could not be confirmed statistically. All these benefits will have great impact in improving the economic viability of the system. The other major objective of project to design, develoment and installation of field prototype of gasifier-based dyeing system is achieved. A gasifier-based dyeing system after testing at Gual Pahari is installed at Pallavi Processes Bangalore.

In this phase, the efforts are made towards developing marketing model for test marketing phase. Sufficient preparatory work has also been undertaken to facilitate launching of test marketing, which includes identification of potential manufacturers, preparation of licensee agreement, and market assessment of selected clusters. In this regards a preliminary review to all intrested manufacturers is done and based on this a manufacturer and a marketing organisation is shorlisted for test marketing phase starting from October 1998. Several other non-technical issues like developing manufacturer base, marketing and financial mechanisms etc. is addressed. In order to widen the base for manufacture of the gasifier-based system a study was carried out to explore marketing potential for different end use application.

Now, the situation is ripe for launching a test-marketing programme for the silk reeling gasifier system.Test marketing needs to be carried out in silk reeling clusters such as Ramanagaram, Kanakapura etc. Since no standard models (marketing and financial) are available, there is a need to evolve suitable mechanisms to commercialize this product.

Therefore, the prime objective of the test-marketing phase is not only to verify the technology acceptability but also to test different marketing and financial models. Hence, it is necessary to try out suitable financial models such as hiring, leasing, BOLT (built own lease transfer), cashdown payment, installment payment, etc. Also, suitable marketing models such as, manufacturing-cum-marketing, manufacturing and marketing by separate agencies, etc. should be examined. About 10-15 gasifier systems are planned to be installed in the test-marketing phase. Monitoring of these systems will be carried out to assess the acceptability of the systems, and other related issues.

There is a need to test the field prototype of gasifier-based dyeing unit and to quantify the comparative benefits of the gasifier-based system over conventional system. Based on the field testing, an economic analysis is planned to be carried out to arrive at the viability of the system.

In order to widen the scope of gasifier-based systems in other silk reeling clusters, we propose to develop a gasifier-based system to suit the Italian basin presently in use in Siddlaghatta. A detailed energy audit needs to be carried out in selected Italian basins to arrive at design database. Based on this, suitable laboratory prototype of gasifier-based system will be designed and tested.

Annexure 1 : Data sheet of Comparison tests in silk reeling units
(Conventional vs Gasifier based ovens)

Project: Gasifier for silk reeling ovens (96RT51)
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi - 110 003

Basic data

Section A (General information)

1. Name of the investigator _____

2. Name of the head of unit _____

3. Experiment code _____

4. Date _____

5. Total time (start - stop) _____

6. House code _____

7. Ambient temperature at 7.30 a.m. _____, 10.30 a.m. _____, 12.00 noon _____, 2 30 p.m. _____

8. General weather condition

   Sunny _____ Cloudy _____ Rain _____

Units used:

- All weight measurements are provided in kilograms
- Time in hour or minutes
- Moisture content in percentage of moisture
- Price in rupees
- Quantity of water in liters
- Quantity of kerosene consumption in milliliters

Ratified by

Partner Name Signature
TERI team member
Owner of the reeling unit or a responsible member

1. TERI team member

D Silk measurement

Parameter	Cottage basin	Gasifier basin
Weight of silk (kg)		
Cost of silk in Rs (selling price - to be procured from reeler or mention the market cost on that day)		
Are silk samples taken?	Yes/No	Yes/No
If yes, from which basins?		
If no, what is the reason?		

E Silk waste

Parameter	Cottage basin		Gasifier basin	
	Time	Weight	Time	Weight
Silk waste				
Cost of silk waste				

F Water consumption

Parameter	Cottage basin		Gasifier basin	
	Cooking	Reeling	Cooking	Reeling
Load - 1				
Load - 2				
Load - 3				
Load - 4				
Load - 5				
(e) Total quantity of the loads (l)				
(f) Quantity of remaining water (l)				
Total quantity of water consumed (e) - (f)				
Water procured from	tap/drum			
Quantity of water procured (l)				
Calorific value of wood (kCal/kg)				
Cost of water (Rs)				

G Time monitoring

Parameter	Cottage basin	Gasifier basin
(g) Ignition time		
(h) Flame time		
(i) Cooking started		
(j) Cooking stopped		
(k) Oven shut down		
(l) Total operation time (g) to (k)		
Total cooking time (i) to (j)		

B Wood measurement

Parameter	Cottage basin		Gasifier basin	
	Time	Weight	Time	Weight
Wood lot - 1				
Wood lot - 2				
Wood lot - 3				
Wood lot - 4				
Wood lot - 5				
(a) Total weight of the lots				
(b) Weight of remaining wood				
Total wood consumed (a) - (b)				
Species of wood used				
Moisture content in the wood				
Calorific value of wood				

C Cocoon measurement

Parameter	Cottage basin		Gasifier basin	
	Time	Weight	Time	Weight
Cocoon weight per basket				
Number of baskets in the batch				
(c) Total weight of cocoons supplied (kg)				
(d) Weight of fresh cocoons remained (kg)				
Weight of recycled cocoons unprocessed (either number or weight)				
Net weight of cocoons processed (c) - (d)				
Moisture content in the cocoons				
Lot	Single/Mixed			
Mode of mixing	Randomly/50% of lots separately			
Quality of cocoons (observation/feedback from owner)	Poor/Medium/Good			
Are the cocoons stifled	(Yes/No)			
If no, what is the reason?				
Price of cocoons	Lot 1 Lot 2 Lot 3 Lot 4			

lode of mixing Please note random mixing is mixing of cocoons from different lots 50% of lots eparately => Take 50% of cocoons from lot 1 and 50% from lot 2 (if there are two lots) mix them and en use for traditional oven and the rest mix separately for use in gasifier based oven).

H Calculation of shell percentage

Date	Sample no.	Cocoon weight (g)	Shell weight (g)	Shell percentage (
	Cottage basin lot			
	1			
	2			
	3			
	Average			
	Gasifier basin lot			
	1			
	2			
	3			
	Average			

I Measurement of Power levels at different vessels

Name of the unit:
Date of experiment:
Ambient temperature at the time of measurement:
Temperature of water in back up drum before the measurement:
Temperature of water in back up drum after the measurement:

Table: Summary table of power levels

Vessel Number	Quantity of water (l)	Total time (min)	Rise in temperature (deg celsius)	Power (kW)
Cottage basin				
1				
2				
3				
4				
5				
6				
Total				
Average				
Gasifier basin				
1				
2				
3				
4				
5				
6				
Total				

Power calculations

Power = (mass of water in liters × Co-efficient of performance of water × Rise in temperature in deg celsius)/(Total time in hours × 860)

J Data on cooking cycles

Name of the unit.
Date of experiment:
Batch time:
Type of oven used: Conventional/gasifier
Quantity of cocoons processed:
Time measurement: Stopwatch/wrist watch

Table A: Details of cooking persons

S. no.	Identification	Name	Male/Female. Age	Remarks
1	A			
2	B			
3	C			
4	D			
5	C			
6	F			

Note. Remarks - Write his/her experience, way of functioning etc.

Vessel Identification (on the backside of the sheet) Other instructions while taking the readings

1. All time details must be in seconds Please use stop watch or watch with a least count of at least 1 second.
2. In the section. comments. write. whether the person cooking is waiting at the oven for the water to get hot. or due to any other problem (W) and Not waiting (NW).
3. The number of cycles that need to be monitored for each person should be equal to the number of persons cooking. i.e. If 5 members are engaged in cooking. take data for 5 cycles While taking data for 5 cycles, the ending time, cocoon in time for 6th cycles also should be noted down.
4. Please note the ambient temperature and humidity before starting these cycles and at the end of the cycles.

Proposal for test marketing phase of gasifier based silk reeling oven

Background

TERI has designed and developed improved prototypes of gasifier based silk reeling oven for use in silk reeling industry This work has been funded by Swiss Agency for development and Co-operation (SDC) The development has so far been materialized by the construction of prototypes proof of concept (Mark 0), Laboratory prototype (Mark 1), Field prototype (Mark 2), Improved field prototype (Mark 3) and Industrial prototype (Mark 4). The field testing of Mark 4 have confirmed that TERI gasifier:

- reduce energy consumption (~60%)
- increase silk yarn yield (~ 350g/100 kg of cocoon)
- improve quality of silk yarn
- increase in productivity

During the development process, which includes very close contact with the reelers, have confirmed the interest of this technology.

Mark `4' industrial prototypes has now been tested at Ramanagaram with more fuelwood saving and other design features. The field testing of these prototype would be completed by June 98 Preliminary market research has indicated that the gasifier has considerable potential, both within the silk industry and in other markets. Hence TERI and SDC are interested in testing the product in their next phase of collaboration starting in October 98. It is also suggested that during the test market phase it is not only the technical aspects of the technology should be tested but also financial and market model should also be tested Meanwhile a marketing team has been formed within the project group consisting of Dr P. Chakravarty, Mr. Sunil Dhingra and Dr. V V.N Kishore from TERI and Ms. Ariane Waldvogel from SDC to look into the commercialization aspects of the gasifier-based systems. The team decided to select proper manufacturing and marketing organization who could be associated with the team for the next phase of test marketing activities In this regard, the team made specific visits to different potential manufacturers/marketing organizations located in Bangalore, Delhi, Coimbatore and Yamunanagar to assess their technical, marketing and financial capabilities. The main purpose of these activities is to do enough groundwork in order to smoothly kickstart the test marketing activities in next phase of the project

Objectives

The proposed consulting mandates consists in recommending TERI and SDC in its work for the current phase of activities, running until September 1999

The main objectives of the consulting mandates are to recommend and deliver TERI.

- Finalization/ ratification of procedure/guidelines for selection of manufacturers and marketing organization
- Actual selection of manufacturer and marketing organization
- Preparation of ToR for the marketing organization(s)
- Preparation of ToR for the manufacturer(s)

- Preparing quality assurance system for system manufacturing.
- Product pricing strategies
- Financial mechanism options (loan, leasing etc.) to promote this system
- Carrying out independent market assessment study for gasifier based systems

Time activity chart

In order to meet the above objectives all the set of activity is sub-divided into following three main sub-contracts along with individual consultant name in bracket .

1. Marketing and management support (Mr. Greg Wishart)
2. Technology support (Mr. Pierre Jaboyedoff)
3. Legal and copy right issues (Dr. YS Rajan)

The issues to be covered under the contracts are categorized under the following 4 broad sub heading·

- Technology - Mark 4 related
- Manufacturer selection
- Technology Transfer
- Market model for test market phase

Time frame 1-9-98 to 30-9-99

ToR for technical assistance to TERI in the development of gasifier-based silk reeling oven (Mr. Pierre Jaboyedoff – Sorana Sa, Switzerland)

Scope of work

The consulting mandate consists in:

- assessment of the technical capability of selected manufacturers,
- assisting selected manufacturer for optimization of design for commercializing the gasifier-based silk reeling system,
- preparing quality assurance system for gasifier-based silk reeling oven manufacturing,
- the development of a strategy for monitoring test marketing of gasifier-based silk reeling systems,
- inputs to improve the field prototype for the gasifier-based dyeing oven,
- inputs in the development of gasifier-based Italian basin (Siddlaghatta cottage basin).

Methodology

The assistance will be performed by the following means:

1. Visits to India in a mission mode.
2. Regular and continuous contacts with the team by appropriate means (phone, fax, e-mail).

Visit 1: Project planning

This is a key stage of test marketing phase for gasifier-based silk reeling ovens The project planning stage will consist of the 7-day visit to India that will include:

- Participation in the review workshop for detailed planning for next phase of this main project (August '98).
- Finalization of test marketing documentation session (technical issues), with GW, YSR.
- Inputs to develop terms of reference (ToR) for manufacturer(s) (with GW,YSR).
- Meeting with shortlisted manufacturer(s) to assess their technical capability
- Inputs to the manufacturers on optimization of design of gasifier-based silk reeling oven.
- Preparing quality assurance system for gasifier-based silk reeling oven manufacturing.
- Inputs to develop protocols for monitoring of gasifier-based silk reeling systems installed during test marketing (with GW).
- Inputs to improve the design of field prototype of gasifier-based dyeing oven.

Visit 2: Mid-phase visit

This stage will consist of a 7-day visit to India to review the progress on the test-marketing phase of the project. The visit will take place in March 1999. The activity to be carried out during this stage will include:

- A review of progress against the test marketing plan (with GW, YSR).
- A review of progress by manufacturer(s) in optimization of gasifier-based silk reeling system design.
- Detailed planning till September 1999, which will include mid course correction, if any (with GW, YSR).
- Inputs to improve the field prototype of gasifier-based dyeing unit.
- Inputs to finalize the design of laboratory prototype of gasifier-based Italian basin (Siddlaghatta cottage basin).

Visit 3: End of the phase review

The stage will consist of 8-days period during August/September 1999. A workshop will be conducted to review the test marketing phase. Also, a review of the design of gasifier-based dyeing oven and design of laboratory prototype of gasifier-base Italian basin (Siddlaghatta cottage basin) will be carried out.

Workload

22 mandays in India
8 mandays in Switzerland
Total: 30 days

ToR for consultancy on marketing and management issues related to the development of silk reeling gasifier (Mr. Greg Wishart – Ashton Court, U.K.)

Scope of the work

The commercialization of the TERI gasifier is a task that may take a number of years Because the gasifier is still under field testing stage, it is not possible to fully define the scope of this work over an extended period of time. Therefore, the management support project will run till September 1999 in the first instance. It may be extended subsequent phases of the TERI gasifier commercialization project by mutual agreement.

The scope of the proposed consultancy can be categorized under the following broad activities.

- Review and assess shortlisted manufacturers in terms of manufacturing and financial capability.
- Actual selection of manufacturer.
- Selection of marketing consultant and preparation of ToR for the consultant.
- Examining the depreciation/tax benefits.
- Market promotion strategy.
- To determine the validity of similar marketing models such as SELCO.
- To examine the marketing methods of existing gasifier manufacturers.

Methodology

The assistance will be performed by the following means:

1. Visit to India in a mission mode
2. Regular contact with the team by appropriate means (e-mail/fax)

Visit 1: Planning for test marketing phase

This is a key stage of test marketing phase. The project planning stage will consist of a 5-day visit to India that will include:

- Participation in the review workshop of the main project for interaction with various partners (August '98).
- Finalization of test marketing documentation (with PJ, YSR).
- Preparation of terms of reference (ToR) for manufacturer(s)/marketing consultant(s) (with PJ, YSR).
- Meeting with shortlisted manufacturer(s) and marketing consultant(s) for test marketing (with PJ, YSR)

Visit 2: Mid-phase visit

This stage will consist of a 5-day visit to India to review the progress on the test-marketing phase of the project. The visit work will take place in March 1999 The tasks to be carried out during this stage will be:

- Review of progress against the test marketing plan (with PJ, YSR).
- Review of preliminary findings from market research.
- Review of progress by manufacturer(s) (with PJ, YSR).
- Detailed planning till September '99, which will include mid course correction, if any (with PJ, YSR).

Visit 3: End of the phase review

The stage will consist of 5-days period during August/September 1999. A workshop will be conducted to review the test-marketing phase and to plan the activity for the commercialization phase of the project.

List of tasks

1. Review of the shortlisted manufacturers.
2. Mission to discuss/assess manufacturers capability both financial and technical.
3. Assistance in actual selection of manufacturer.
4. Finalization of ToR for manufacturer.
5. Finalization/ratification of criteria for selection of marketing consultant.
6. Initial discussion with market consultants.
7. Mission to assess the marketing consultants.
8. Assistance in actual selection of marketing consultant.
9. Finalization of ToR for marketing consultant.
10. Review of market assessment study findings.
11. Determine the validity of the marketing model likely to be adapted.
12. Product pricing strategies.
13. Planning for test marketing phase.
14. Mid-term review of test marketing phase.
15. Business plan for commercialization phase.

Workload and travel

15 days input by a project manager/senior consultant @ SF 928/day
Total manpower cost: SF 13920

Visit to India

3 trips to India
15 days subsistence in India @
Internal travel in India @
Communication etc. @
Expenses contingency @

Grand total

Questionnaire used for the selection of marketing and manufacturing organization

Manufacturer

Factual info

1. What are the products manufactured?
2. What is the geographical area of operation?
3. What is the turnover?
4. What is the type of the firm? (Partnership, Private Limited etc.)
5. Is there a dealership network for the products made?
6. How are the products marketed?
7. Is after-sales service provided? If so, what is the mechanism? (AMC, guarantee, etc.)
8. Is there any non-standard item being manufactured? If so, name it.
9. How was the technology obtained? From whom? When was it obtained?
10. What were the terms of purchase/license for the technology?
11. Is the company well equipped for sheet metal/refractory lining work?
12. Is he willing to enter into a contract with TERI?

Other info

1. Is he familiar with the silk reeling sector?
2. Is he willing to work with TERI for cost reduction if necessary?
3. Does he like to market the gasifier system himself? If so, how?
4. If not, how would he like to promote sales?
5. Is he willing to develop linkages with financial companies/commission agents etc.?
6. Does he know of other companies suitable to take up manufacture of gasifier systems?

Info about suppliers of machinery to reelers

1. What items does he supply to the reelers?
2. Since how long has he been supplying?
3. What are the costs of the lowest and highest priced items supplied?
4. How are the items sold? By direct cash purchase, by cheque payment, by installments, etc.?
5. If purchased through loans, details known (name of the bank, interest rate, mortgage, guarantee, method of collection etc.)
6. Does he provide after-sales service? If so, details.
7. Does he have competitors? If so, details.
8. How does he market his machinery?

Info about market consultants

1. What are the services provided?
2. Give a list of recent customers and the nature of services provided.
3. Has he provided consultancy to anyone dealing with silk or related industries?
4. Can he actually undertake market survey for the gasifier system?
5. If so, how does he propose to do it?
6. Can he identify suitable manufacturers? If so, how?
7. Can he undertake development of a market promotion strategy for the system?
8. Can he suggest other agencies for market consultancy?
9. What are the charges for consultancy?

Report on survey of marketing and manufacturing organizations to launch test marketing

I. Vijay Engineering, Bangalore

Persons met Mr. A. Narendrappa
Mr. Ravi Kumar (proprietor)

Factual Info

1. Job works mainly fabrication.
2. Bangalore
3. 20 laks per year [20 - 22% growth rate]
4. Proprietary [in business since 1988].
5. NO
6. Personal contacts [fathers]
7 After sales service provided of course weak. For gasifier 6 months guarantee proposed, will repair manufacturing defects, replace spare parts.
8. Everything is non-standard.
9. Not applicable
10. Not applicable.
11. Welding facilities available, hand operated shearing machine, No plate rolling facilities, no refractory casting facilities. Min thickness of SS willing to undertake for welding is 1.6mm. For casting proposes, to get trained staff and to get the job done in-house.

Other Info

1. Superficially. He off course has contacts at the silk sector.
2. He cannot reduce the cost of SS component since that has to be purchased at the open market while MS he can purchase form some kind of bulk market at reduced price reduced price.
3. Willing but not capable.
4. Not applicable
5. Not capable as we did not have any proper response.
6. Not applicable.

Summary

Not very clear on quality control aspects. A present margin kept on job orders is 15%. Fabrication cost indication Rs 30/kg for MS (hot rolled sheets), Rs 200/kg for SS. Total 9 workers [5 skilled rest unskilled]; the proprietor is diploma holder. General impression was not favorable to have him as a manufacturer for our product, considering his present technical incapability.

II. Newfield Engineers, Bangalore

Persons met Mr. K. A. Sampath Kumar

Factual Info

1. Mostly heavy fabrication jobs, Contract for erection and commissioning
2. Central, western & south India.
3. 15 laks [stable for last 3 years]
4. Proprietary
5. Personal contacts
6. By personal contacts.
7. Guarantee 1 year for his own design as well as for the material.
8. All non-standard.
9. Not applicable
10. Not applicable.
11. Facilities for welding available. No facility for sheet cutting, refractory lining etc.
12. Yes. He is more interested to acquire gasifier technology than the present product.

Other Info

1. No
2. Possibly
3. No, very clear about it
4. He is not willing to be involved with marketing at all.
5. Yes, as long as it reduces his risks.
6. Not applicable.

Summary [*company profile enclosed*]

Technically he is more capable [2 engrs including him, 2 skilled, 1 unskilled]. Cost of fabrication 10-16mm thick sheet - Rs 34 - 36/kg, 1.5mm sheet Rs 40 -42/kg for MS sheets (hot rolled). No indication for SS. He can take care of installation, training of the users etc. However considering the past background, his keenness to get the gasifier design, his indication of gasifier usage for some other drying applications and his not too transparent attitudes, it was felt that he should not be involved in our project in any manner, since most of the kind of activity which he proposes to do can be done by some mktg. organization and the inbuilt margins in this case will be lesser.

III. Greenergy Systems, Bangalore

Persons met Mr. Mathew Philip
Mr. K. S. Shivanand
Mr. Terrance

Factual Info

1. Marketing organization selling Boilers of a reputed make namely; Veesons. Presently the agent for selling gasifier of Ankur, capacities 100kWe and above. Having proven track record of selling gasifiers in the difficult market scenarios
2. Whole of South India [4 states, presently major focus in Karnataka]
3. 3 crores from boilers sales in the last year.
4. Partnership [2nd year in operation]
5. They market themselves

6. Through personnel contacts and close follow-up
7. They provide erection & commissioning support for boilers and gasifiers as well as take care of the after sale service under AMC or warranty
8. Not applicable
9. Not applicable
10. Not applicable
11. They have enough experience about sheet metal/ refractory lining work with respect to boiler and gasifier.
12. Yes

Other Info

1. Yes
2. Yes
3. Yes, based on his previous experience selling capital equipment introducing a new concept
4. Not applicable
5. Yes
6. Not applicable

Info about Market Consultants

1. They provide erection & commissioning support for boilers and gasifiers as well as take care of the after sale service under AMC or warranty
2. Mainly doing business in rice mills and solvent extraction plants
3. Not applicable
4. Yes
5. To be discussed
6. He can manufacture himself
7. May be
8. Not applicable
9. Not applicable

Summary

Strong marketing organization having three partners (all engineers) along with five other engineers as staff. They have about 10 years of experience selling boilers and in last two years selling gasifiers also, as marketing agents. They have close interaction with different fabricators and boiler grade manufacturers. They also have close connection with fabricators dealing with thin gauge SS sheet metal works. They plan to undertake total responsibility of manufacturing and marketing of gasifier based silk reeling ovens. Fabrication cost Rs 60-70 per kg for MS (cold rolled) sheets and about Rs 110 per kg for SS. They have agreed to undertake total accountability for meeting quality, after sales service, meeting sales target etc. The discussions and observations led us to believe that they have adequate capability to undertake the above responsibility and hence it was felt that this agency could be short-listed for this purpose.

IV. Jaya Boilers, Coimbatore

Persons met Mr Kamath (Partner)
Mr P S Kamath (MD)

Factual Info

1. Boiler non-IBR - 4.9 Gallons working at 5PSI IBR - 50 kg to 5 tones. They make both fluidized and oil fired boilers.
2. South India
3. 30 crores - indicated by PBK, 3 crore - indicated by senior Kamath
4. Partnership
5. 1 agent (individual) Bangalore based for Karnataka and Andhra
6. Through own agents
7. Presently, there is an E&C and after sales team available
8. Some variants of boiler
9. Obtained by the father of Mr Kamath (partner) rest data has not been given
10. Not known
11. Yes - for MS sheet fabrication work, ceramic lining (we need to give the details about ceramic)
    No - SS jobs however willing to acquire TIG/welding machine for thin SS welding (1 mm etc.) plans to use boiler waster for gasifier.
12. Yes

Other Info

1. No
2. Yes, ready to reduce margin for first few units
3. Using boiler waste to reduce cost
4. To start with same agent to work for gasifier. Wants to appoint a retired silk dept official for marketing
5. No concrete ideas
6. Not applicable

Summary

Deliberately avoided giving information on turnover and present profit margins. Having some contacts with government silk institute, 3-4 boilers supplied, wants to use the existing agent (1) only for initial marketing and later to appoint a retired Govt. silk sector man for marketing. Not having many qualified staff (avoided giving exact info - having separate design department). Does no appear to have good business at present. Many of the finished boilers for NDDB and other organizations have been held up by themselves for clearance to supply. Indicated weak plans to appoint separate staff for gasifier purposes. No idea of the silk market potential for this unit. Keen to have our technology. Wants our drawing for cost estimates (no price indications given otherwise). Not very open on giving crucial fact hence transparency is doubted. Cost reduction aspect doubtful. Avoided many times telling fabrication cost. Could be considered for manufacturing but not marketing. Final finished job is good looking.

V. Altech Induatries, Coimbatore

Person met Dr. S.B. Vijayaraghavan (Ph.D., Proprietor)

Factual Info

1. Lab equipment for engg. Colleges
2. Mainly TN also South India
3. Total 88 lakhs - Altech - 65 lakhs, Werner 23 lakhs. Staff 2 Engineer (Diploma) + himself (Ph.D.) 1 Exp. supervisor + 8 skilled workers
   Growth rate - about 7-8 lakhs per year
4. Partnership with wife and mother
5. No
6. Personal contacts, word of mouth, paper ad from colleges
7. No sales service required for the present products. He will appoint after sales staff
8. College equipment
9. Own R&D
10. Not applicable
11. Fabrication work done outside, only machining done here
12. Yes, after knowing the volumes.

Other Info

1. No
2. May be - his present margin is 30% or more, for gasifier at least 20%.
3. No
4. No idea he will only do the manufacturing
5. No
6. Not applicable - suggested that we should go to boiler manufacturers.

Summary

His present margins are very high. He will subcontract job. Not very clear about refractory work aspect. Not willing to make any investment now. Not dealing with SS fabrication. He will ask for high margins. Hence not suitable choice.

VI. Mr. Muthuraman, Coimbatore

Factual Info

1. None
2. None
3. Zero
4. Partnership only in paper
5. No
6. Not yet marketed as CSTRI did not recognize their machine
7. Not applicable
8. Not applicable
9. Not applicable
10. Not applicable
11. No machine as on date. Indicated plans of purchasing; welding, lathes, bending machines, if our contract is obtained Absolutely no idea about refractory work
12. Yes - lumpsum in installment - initial support for few systems

Questionnaire used for the above survey

Manufacturer

Factual Info

1. What are the products manufactured?
2. What is the geographical area of operation?
3. What is the turnover?
4. What is the type of the firm? (Partnership, Private Limited etc.)
5. Is there a dealership network for the products made?
6. How are the products marketed?
7. Is after-sales service provided? If so, what is the mechanism? (AMC, guarantee, etc.)
8. Is there any non-standard item being manufactured? If so, name it.
9. How was the technology obtained? From whom? When was it obtained?
10. What were the terms of purchase/license for the technology?
11. Is the company well equipped for sheet metal/refractory lining work?
12. Is he willing to enter into a contract with TERI?

Other Info

1. Is he familiar with the silk reeling sector?
2. Is he willing to work with TERI for cost reduction if necessary?
3. Does he like to market the gasifier system himself? If so, how?
4. If not, how would he like to promote sales?
5. Is he willing to develop linkages with financial companies/commission agents etc.?
6. Does he know of other companies suitable to take up manufacture of gasifier systems?

Info about Suppliers of machinery to reelers

1. What items does he supply to the reelers?
2. Since how long has he been supplying?
3. What are the costs of the lowest and highest priced items supplied?
4. How are the items sold? By direct cash purchase, by cheque payment, by installments, etc.?
5. If purchased through loans, details known (name of the bank, interest rate, mortgage, guarantee, method of collection etc.)
6. Does he provide after-sales service? If so, details.
7. Does he have competitors? If so, details
8. How does he market his machinery?

Info about Market consultants

1. What are the services provided?
2. Give a list of recent customers and the nature of services provided.
3. Has he provided consultancy to anyone dealing with silk or related industries?
4. Can he actually undertake market survey for the gasifier system?
5. If so, how does he propose to do it?
6. Can he identify suitable manufacturers? If so, how?
7. Can he undertake development of a market promotion strategy for the system?
8. Can he suggest other agencies for market consultancy?
9. What are the charges for consultancy?

7. About their product they have no opinions on such issues. So this point is not applicable.
8. The rural technology about which they are talking and the details of, which is not clear, is non-standard.
9. From ASTRA Dept. IISc., Bangalore
10. Not known
11. They are not aware of any manufacturing processes.
12. Not very encouraging and wants to put certain pre-requisites as discussed in the summary.

Other Info

1. Little familiarity.
2. No as they are not aware of any manufacturing processes or practices.
3. Yes. Please refer summary below.
4. Not applicable
5. Finds it too premature to discuss about it in this initial stages.
6. No.

Summary

They showed inclination to handle both manufacturing and marketing. However, the above background shows practically no experience of manufacturing. Therefore this organization does not appear to be very suitable for the manufacturing responsibilities. Regarding marketing they feel that since it a new product also because we are approaching a very conservative industry it is required that first 30 units may be installed at 100% subsidy. In addition TERI must also offer proper after sales service, annual maintenance contract etc. The complete expenditure for the above must be borne by TERI and only after the above phase there role can be more responsible. They called for more discussion to arrive at precise role for each organization as well as inclusion of above terms and conditions in the contract to proceed further. Based on the above discussion it was decided that they need not be considered for our purposes.

VIII. Chandrapur Works, Yamuna Nagar, Haryana

Persons met Mr. Sudhir Chandra
Mr. Sunil Chandra

Factual Info

1. Mini cement plant 50-200 + PD, also manufacture sugar mill machinery
2. Nation wide
3. 6-7 crores, average growth rate of 20% in the last 5 years
4. A corporate firm
5. No
6. Direct marketing. About the new projects info is obtained from govt. licensing agencies as well as from financial institutions.
7. For minor job locally trained people (associates) attend to it while for major jobs the company sends technicians
8. No
9. Technology for mini cement plant was obtained from "Cement Research Institute", Vallabhgarh, Haryana
10. Not known
11. Yes
12. Definitely, already has a contract with TERI.

Other Info

1. No
2. Yes, but overheads are high and looking for a sales volume of about 20 systems for month for a practical cost reduction solution.
3. No
4. His is not willing to enter the sales domain and is keen to work closely with a marketing organization that can take care of sales
5. Yes but not very relevant since he is not entering the marketing
6. Not applicable

Summary

Very positive, long term perspective with gasifiers, progressive, can be considered as a manufacturing organization in association with a strong marketing agency. Issue of cost reduction is feasible with certain minimum sales volume (20 systems/month). Transportation to Karnataka due to addition of shipping cost to the price has to be evaluated carefully. Indicated fabrication cost Rs. 350/kg for SS.

IX. TIDE Technocrats Pvt. Ltd., Bangalore

Persons met Mr. K.J. Dinesh

Factual Info

1. Mainly technical consulting organization also planning to market some technological product for rural areas developed by ASTRA group of IISc, Bangalore.
2. Mainly Karnataka
3. Did not tell
4. Private.
5. No
6. Direct Marketing [still in the planning stage]

Other Info

1. Yes, but no idea about market
2. Yes, no definite idea or own idea.
3. Yes - but having no concept
4. No idea
5. Not clear, wants our help and guidance
6. Not applicable

Summary

Having no factory or machine, also no idea of marketing. Suggests that we should put units in district training centers for silk reelers, which is also the market for cocoons. They want that first few units to be given on heavy discount by TERI to the market, also they need advice of TERI on marketing aspects. Due to their lack of experience, it was felt that we need not consider them seriously.

VII. Urjex Boilers, Meerut

Person met Mr M P Rai, M.D.

Factual Info

1. Heat exchangers and boilers
2. North India
3. 2 crores (previous two years 1.75 & 1.25 crores)
4. Partnership
5. Associates at different places, kept on commission basis
6. Direct marketing and also through associates
7. Yes, a team of trained professional available at Delhi office
8. No
9. Through his own past experience
10. Not applicable
11. Yes
12. Yes
13. Reasonably good for their existing product

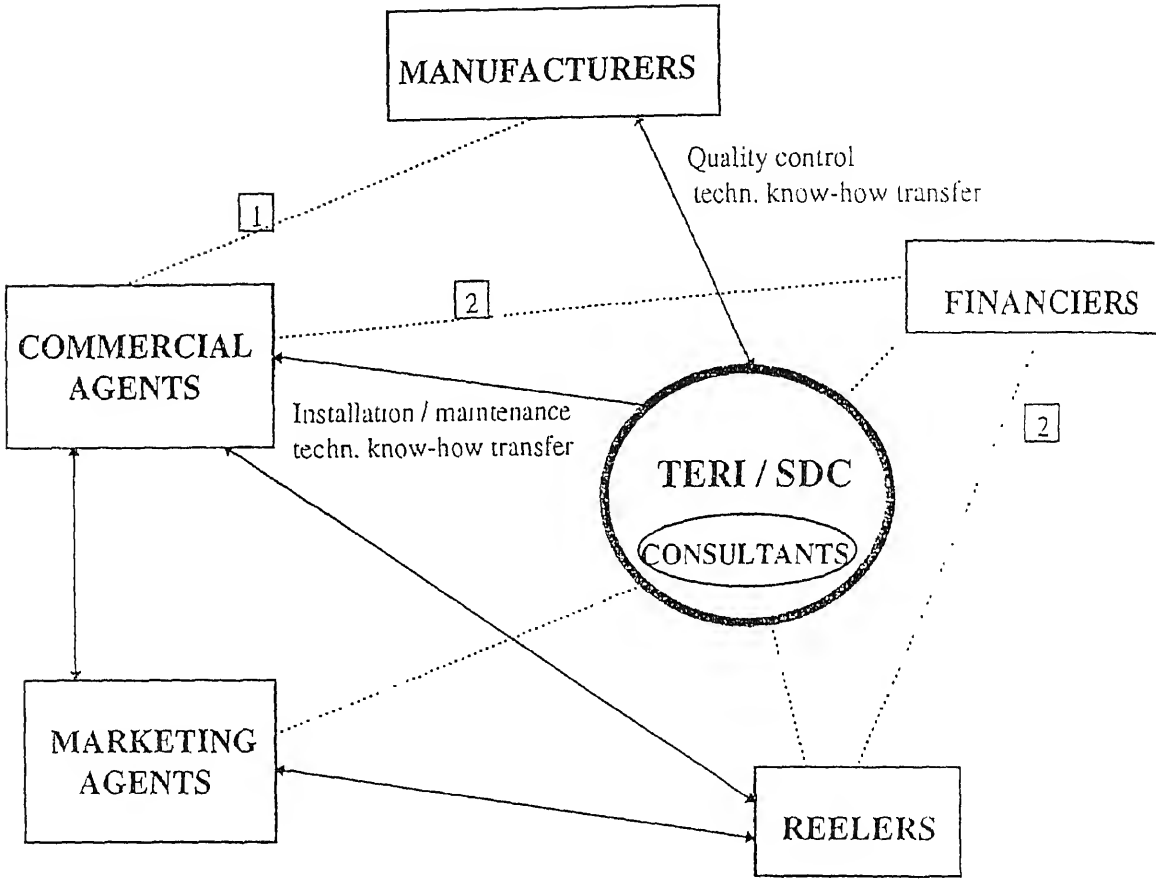
Other Info

1. No
2. Yes
3. Not at present. May be after the market develops
4. Through collaboration with a separate marketing agency
5. Yes but he is not presently going to be involved for marketing
6. Not relevant

Summary

Staff about 80 (60 at works and 20 Admin and marketing [60 = 6 engineers + 10 skilled + 15 unskilled + 6-7 service engineers + 10 semi skilled + 15-20 helpers]. Present turnover 2 crores, progressive. Interested for a long-term relation with TERI on gasifier. Already manufactured 2 mark - 4 units for TERI which are in operation at present at Ramanagaram. Can handle 1.0mm SS sheet fabrication. Having + IG welding machine. As per him the market cost of fabrication = [Material cost / 0.55]. Can be considered as a manufacturer.

BASIC FRAMEWORK FOR THE MARKETING & COMMERCIAL PHASE



certain interactions ⟷
possible/ potential interactions .....
certain interactions ⟷
possible/ potential interactions . .
1 identification of a manufacturer and (?) commercial agents
2 assessment of i) socio-eco. status of reelers community
ii) existing financial mechanisms

Annexure 6

License Agreement

THIS AGREEMENT is made on this..... day of..... 1997 by and between TERI, a Society registered under the Societies Registration Act, 1860, of Darbari Seth Block, Habitat Place, Lodhi Road, New Delhi - 110 003 (hereinafter referred to as "TERI" which expression shall where the context so admits include its permitted assigns) of the ONE PART and manufacturer (hereinafter referred to as "MANUFACTURER" which expression shall where the context so admits include its permitted assigns) of the Other Part.

WHEREAS TERI has developed and is in possession of valuable proprietary information and know how relating to a process and systems of

(i) A Gasifier for use in variety of heating applications such as silk reeling, yarn and fabric dyeing, large scale cooking, bakery, drying of agriculture products and (ii) a gas cooler for use to cool and clean the gas (iii) a drier for drying of cash crops (iv) a silk reeling oven having such a gasifier for cottage basin silk reeling unit developed under the funding of Swiss Agency for Development and Co-operation (SDC) (hereinafter singularly or jointly referred to as "the invention").

AND WHEREAS TERI has applied for **a patent under** patent application no. 548/DEL/91 dated 24 June 1991, patent application no. 549/DEL/91 dated 24 June 1991, patent application no. 600/DEL/91 dated 5 July 1991 and patent application no. _____/DEL/97 dated _____, relating, interalia, to the invention (hereinafter singularly or jointly referred to as "patent application").

AND WHEREAS, MANUFACTURER is interested in acquiring the Know How (hereinafter referred to as 'KNOW HOW') relating to the invention for purpose of manufacturing the system of (i) gasifier for use in silk reeling oven only and (ii) a silk reeling oven having said gasifier (hereinafter jointly referred to as "SYSTEM") and is desirous of obtaining a license on the KNOW HOW and patent when granted on the patent application.

The license under this agreement cover use of gasifier for silk reeling industry only **AND WHEREAS**, TERI hereby agrees to grant MANUFACTURER as license on the KNOW HOW and the patent when granted on the patent application in accordance with the terms and conditions hereinafter contained and mutually agreed upon.

NOW THIS AGREEMENT WITNESSETH AS FOLLOWS:

1.1 In this Agreement, including the recitals and schedules hereto, the following terms used herein shall have these meanings:

A) **"Know How"** shall mean TERI's experience, knowledge, technical data and other information relating to the invention existing with TERI on the date of this agreement and shall include any subsequent improvement or modification relatable thereto and made by TERI during the period that this agreement is in force.

B) **"Patent Application"** shall mean patent application No.....DEL/97 dated..... filled by TERI relating to the invention and shall include all subsequent patent applications made by TERI relating to improvements or modifications of the invention;

C) **"Patent"** shall mean the patent if and when granted on the patent application and shall include such patents if and when granted on the subsequent patent applications.

D) **"SYSTEM"** shall mean the system of gasifier based silk reeling oven made by the know How.

Article 2

GRANT BY TERI

2.1 In consideration of the payment by MANUFACTURER to TERI a lumpsum fee of Rupees25,000 (Twenty five thousand), the receipt of which is hereby acknowledged, and the payment of royalty hereinafter specified, and the observance and performance by MANUFACTURER of the covenants herein contained and on its part to be observed and performed, TERI hereby grants this non exclusive license to MANUFACTURER to work and use the know how and the patent when granted on the patent application in any manner thought fit by MANUFACTURER from the date hereof which shall include the right to manufacturer and sell the SYSTEM.

2.2 **TERI** hereby covenants with MANUFACTURER that TERI has good right to grant the license herein contained in the manner aforesaid and that MANUFACTURER and the permitted persons deriving title under MANUFACTURER may at all times hereafter and during the continuance of this agreement enjoy the full benefit thereof without any interruption or disturbance from or by TERI or any person rightfully claiming under TERI.

2.3 TERI hereby covenants with MANUFACTURER that MANUFACTURER paying the royalties hereby reserved and observing and performing the covenants by MANUFACTURER herein contained, MANUFACTURER shall and may at all times during the continuance of this license enjoy and exercise all rights granted without interruption or disturbance by TERI.

ARTICLE 2

UNDERTAKINGS BY MANUFACTURER

3.1 **MANUFACTURER** shall pay to TERI during the complete period that this agreement is in force a royalty of five percent of the selling price of the SYSTEM manufactured and sold by MANUFACTURER, excluding all Government taxes and levies or Rs 2500/- (Two Thousand five hundred) which ever is maximum.

3.2 The royalties referred to in Article 3.1 hereinabove shall become due on the first day of April each year in respect of the SYSTEM manufactured and sold by MANUFACTURER during the preceding year and shall be paid by the first day of May of that year.

3.3 **MANUFACTURER** shall within fourteen days of first April of each year deliver to TERI, its attorneys or duly authorized agents, a true and complete statement in writing of the SYSTEMS manufactured and sold by MANUFACTURER during the preceding year and of all royalties payable to TERI in respect thereof and duly certified by an auditor or MANUFACTURER or provisionally by a director of MANUFACTURER to be confirmed by the auditor within six months after submission of the provisional statement.

3.4 **MANUFACTURER** shall permit TERI, its attorneys, duly authorized agents or representatives at all convenient and reasonable times to enter into and upon the premises of MANUFACTURER where such SYSTEMS manufactured as aforesaid may be stored or are manufactured or sold under this license for the purpose of inspecting the same and the manner of manufacturer thereof and generally to ascertain that the provisions of this license are being completed with.

3.5 **MANUFACTURER** shall permit TERI, its attorneys or duly authorized agent at all reasonable time to inspect, take copies or extracts from any books of accounts, papers and documents containing such information and particulars as may be necessary and/or proper for enabling the amount of royalties hereby reserved to be conveniently determined.

3.6 It will not be open to Manufacturer to claim any exemption from or reduction in the payment of royalty accruing under this agreement on the plea of having effected any improvement or modification in the Know How and Manufacturer shall be liable for the payment of royalties for all SYSTEMS by it and covered by this agreement.

Article 4

LICENSE OF PATENTS

4.1 TERI hereby grants a non-exclusive license on the patent, if and when granted on to patent application, and without the payment by Manufacturer of any additional charges or royalty whatsoever.

4.2 TERI and Manufacturer hereby agree that this agreement shall also be constructed as a license agreement on the patent, if and when granted, and that TERI shall execute and do such other assurances and things including records of the agreement, necessary desirable to give effect to the license, including the license in respect of the patent, the expenses of which shall be bone by Manufacturer.

4.3 TERI hereby agrees to pay the costs for renewal of the patent, and that if TERI fails to do so for any reason whatsoever, then Manufacturer shall be entitled to do so and the costs thereof shall be deducted from the payment of the next royalty due to TERI.

VALIDITY OF PATENT

5.1 **MANUFACTURER** shall not at any time herein after or during the subsistence of this agreement, directly or indirectly, raise any question concerning or take any objection on any ground whatsoever to the validity of the patent and further hereby accept the validity thereof.

Article 6

MARKET DEMAND

MANUFACTURER shall make its best endeavor to work the Know How, manufacturer and sell the SYSTEMS on a commercial scale and to meet the demand of the market to an adequate extent.

Article 7

IMPROVEMENTS ON KNOW HOW

7.1 During the continuance of this license, TERI and Manufacturer shall promptly disclose to each other all improvements or modifications made by either partly relatable in respect of the Know How and that in the instance;

Where the improvements or modifications have originated from TERI, thenManufacturer shall have the right to use the improvement and modification without the payment of any additional charges or money to TERI provided that in the event of TERI obtaining a patent for the improvements or modifications, and which improvements or modifications are thereafter used by Manufacturer then this agreement shall continue till the expiry of the patent thereon;

b.) the improvement or modifications have originated from Manufacturer, it shall disclose the same to TERI and Manufacturer shall have the right o file at its own expense patent applications in respect of such improvements or modifications, and that any patent or patents granted on such patent application or applications shall be property of Manufacturer provided that Manufacturer shall not claim any reduction in the payment of royalty and, further, that this agreement is in force, assign or license to any third party such patent or patents without the written consent of TERI and, further provided that other licensees of TERI shall have the right to use such improvements or modification without the payment of money to Manufacturer, or, should Manufacturer decide not to file any patent applications thereon, Manufacturer shall and upon written request and at the expense of TERI allow TERI to file patent applications covering such improvements or modifications and the patents and the rights appertaining thereto shall accrue to TERI.

7.2 The terms and conditions contained herein shall apply to the patent on the improvements or modifications referred to in this article.

Article 8

USE OF KNOW HOW

Manufacturer shall not directly or indirectly and either by itself or by itself or by its agents use or exercise the Know How or work the patent or any part thereof otherwise than in accordance with this license.

Article 9

CONFIDENTIALITY OF KNOW HOW

9.1 The Know How constitutes the valuable secret property of TERI. In order to safeguard the rights of TERI, Manufacturer shall maintain secret and confidential and shall not disclose directly or indirectly to third parties, except as may be necessary in the ordinary course of business, any of the information received according to this agreement during its duration and after its expiration, unless such information has become general knowledge provided however that Manufacturer shall always during the term of as well as after expiration of this agreement be entitled to use the acquired Know How for its own manufacturing purposes. Manufacturer shall cause its present and future employees who any come in contact with such secret and confidential information to sign such documents as may be advisable to protect the confidentiality of the Know How in accordance with this Article.

Article 10

INFRINGEMENT OF PATENTS

10.1 TERI shall at the request of Manufacturer or otherwise commence all necessary legal or other proceedings in respect of any infringement or suspected infringement of the Patent which are in the name of TERI for effectually protecting and defending the same, and take all such steps as do all such things as may be necessary for prosecuting any such proceedings and any damages awarded thereon shall be shared equally between TERI and Manufacturer, or in their respective share to the contribution of such costs by either party.

Article 11

TERMS OF AGREEMENT

This agreement shall be in force for a period of fourteen years from the date hereof or the last of expiry of any of the Patents, whichever is later.

Article 12

TERMINATION DUE TO NON MANUFACTURER

If the Licensee shall not have commenced the manufacture and sale of the SYSTEMS within..... months from the date of this agreement, this agreement may be terminated by TERI giving notice of termination in the manner provided subsequently herein, the effective date of termination to be fixed by said notice, at a date not less than thirty (30) days after the date serving said notice of termination, provided, however, that should circumstances beyond the control of Manufacturer prevent it from commencing such manufacture and sale, as provided above, by the aforementioned date, TERI will grant an extension of time equivalent to that lost by Licensee through circumstances belong its control which will be no longer than six months.

Article 13

GENERAL TERMINATION

In the event of the happening of any or all of the following acts or conditions, this agreement shall terminate and be of no further force or effect;

If Manufacturer shall become bankrupt or insolvent or make an assignment for the benefit of its creditors, whether or not TERI may not have given notice of termination.

b) If Manufacturer shall default in the performance or observance of any term, condition, or agreement herein specified to be performed or observed by the Manufacturer and shall fail to remedy such default within sixty (60) days after the service of notice of such default and demand that the same be remedied;

c) The appointment of trustee or receiver of Manufacturer;

In the event that the royalty, payable by Manufacturer to TERI is less than Rupees Fifteen Thousand for any one year then TERI has the right to forthwith terminate this agreement without notice.

e) In the event of a termination all rights of Manufacturer hereunder forthwith shall terminate and all obligations of the Manufacturer hereunder the unsatisfied forthwith shall become due and payable.

Article 14

NOTICE

Any notice required or permitted to be given under this agreement shall be deemed sufficiently given if mailed by registered air mail postage pre-paid, addressed to the other party to be notified at the address shown at the beginning of this agreement or as such other address as may have been furnished in writing by one party to the other.

Article 15

INDEMNITY

Manufacturer shall indemnify and hold harmless TERI against all claims, demand, law suits and all cost and expenses in connection therewith including the legal fees which may be brought or asserted against TERI on account of breach, mistakes or negligence of Manufacturer its employees or agents in connection with its obligations under or on account of this agreement.

Article 16

ASSIGNMENT OF AGREEMENT

This agreement is personal to the parties hereto, and either party shall not be entitled to assign, charge, transfer or otherwise dispose of this agreement or any of its benefits or obligations hereunder or any part thereof without the prior written consent of the other.

Article 17

WAIVER

The waiver by either party of any breach of any term, condition, or agreement herein contained shall not be deemed to be a waiver of any subsequent breach of the same or any other term, condition, or agreement herein contained.

Article 18

SUBSEQUENT TO TERMINATION

Upon the termination of this agreement Manufacturer shall forthwith discontinue use of the Know How and refrain from manufacture and sale of the SYSTEM.

Article 19

FORCE MAJEURE

The terms and conditions of this agreement shall be considered to be suspended if either party is caused to suspend fulfillment of its obligations by Act of God, civil commotions, riots, legal moratorium, war, revolution, action by Government, or any other force majeure reasons preventing operations under this agreement. In such event, the parties will make the best possible arrangement by mutual agreement and according to the circumstances and that upon elimination of the cause for suspension, this agreement will become effective again. If Manufacturer remains in operation during any such event, it shall accumulate royalties and remit same to TERI as soon as possible after such event is terminated.

Article 20

AMENDMENTS_

This agreement shall be the sole repository of the terms agreed to between the parties and that all amendments and modifications or deletion of any clause of this agreement will not be valid unless agreed upon and confirmed by both parties in writing.

Article 21

RELATIONSHIP BETWEEN PARTIES

The relationship between TERI and Manufacturer in contractual and no provision of, or act performed, under this agreement shall be construed and constituted either party to agent of the other.

Article 22

SERVICEABILITY

If any term, paragraph or provision of this agreement shall be held to be invalid for any reason whatsoever.

WITNESS

(WITH NAME AND ADDRESS)

SIGNED BY

(TERI)

SIGNED BY

Annexure 7

THE PATENTS ACT, 1970

SPECIFICATION

SECTION 10

TITLE

"A COOKING/HEAT RECOVERY DEVICE"

APPLICANT

TATA ENERGY RESEARCH INSTITUTE, a Society registered under Societies Registration Act, Darbari Seth Block, Habitat Place, Lodhi Road, New Delhi-110 003. INDIA.

The following Specification Particularly describes and ascertains the nature of this invention and the manner in which is to be performed.

L. S. DAVAR & CO.
Patent & Trade Marks Attorneys,
CALCUTTA/DELHI

This invention relates to a cooking/heat recovery device for the cooking of cocoons.

The coocoons are cooked in the cooking oven for recovery of the silk yarn therefrom. The cooking oven and heat recovery drum for cottage basin is known in the art for cooking the cocoon. The device comprises a plurality of cooking pot for containing water and cocoons to be cooked. The heating of water contained in the cooking pots is effected by using wood as fuel, A drum is provided with the structure on which cooking pots are supported so as to utilize the heat from the flue gases for heating water. The hot water in the drum is used to make up the level of water in the pots manually.

There are certain disadvantages associated with the known cooking/heat recovery device. One of the main disadvantage is that there is no control of the temperature in the cooking pots.

Another disadvantage is that the complete heat energy is not utilized and wasted in the form of flue gases.

Yet another disadvantage is that due to the burning of wood, pollution is caused to the environment.

Still another disadvantage is that there is no control in the quality of production of the silk yarn due to variation in the temperature of the different cooking pots.

Therefore the main object of the present invention is to propose a cooking oven and heat recovery device which obviates the disadvantage associated with the prior art.

Another object of this invention is to propose a cooking oven and heat recovery device wherein the complete heat energy is utilized by the heat recovery unit.

Yet another object of this invention is to propose a cooking oven and heat recovery device wherein no environmental pollution is caused as the wood is converted in the form of producer gas by using a gasifier.

Still another object of this invention is to propose a cooking/heat recovery device wherein the cooking temperature in the cooking pots is maintained uniformly.

According to this invention there is provided a cooking/heat recovery device comprising a plurality of perforated cooking pots,supported in a common bath, a burner adapted to be connected with a gasifier being provided for heating said common bath, a heat recovery unit being provided adjoining to the cooking bath such that to utilize the heat energy entrapped in the flue gases, a level control means being provided with the said cooking bath such that to control the level of the water in the cooking bath, a gasifier being provided on one side of said common bath for producing and supplying producer gases to said burner.

In accordance with this invention the cooking oven and heat recovery device comprises a plurality of perforated cooking pots supported on a common cooking bath. A burner adapted to be connected with a gasifier is provided below the common bath for heating the liquid medium/water contained in the bath. The burner is disposed within a sealed chamber having the common bath and heat recovery unit supported thereon and being extended into said chamber to recover the heat energy from the flue gases passing through the heat recovery unit. Level control means for example flot valve is provided with the common water bath for maintaining the

level of water in the common water bath automatically. A gasifier is provided on one side of the common bath for producing producer gases by burning wood therein. The producer gas is supplied to the burner through a gas conveyer pipe.

The gasifier according to this invention has a metallic cylindrical reactor having a feeding hopper provided on the top end of the reactor. The combustion and reduction zone of the reactor is provided with line refractories. An inlet is provided to supply the air into the combustion zone, required for producing the producer gases. Grate shaking means are provided for shaking the grate of the gasifier so as to remove the ash contents therefrom. An ash pit tank is provided below the reactor for converting the ash into charcoal.

A cooking/heat recovery device according to a preferred embodiment is herein described and illustrated in the accompanying drawings wherein:

Fig.1 shows the eluvational view of the device of this invention;

Fig.2 shows the sectional view of the present invention;

Fig.3 shows the top view of the cooking/heat recovery system; and

Fig.4 shows the system according to another embodiment.

Referring to the drawings particularly fig.1 the cooking/heat recovery device of this invention has a plurality of perforated cooking pots 1 supported on a common cooking bath 2. A burner 3 adapted to be connected with a gasifier 4 through a gas conveyaning pipe 5 is provided below the common cooking bath 2 for heating the liquid medium/water contained in the cooking bath 2. The burner 3 is disposed within a sealed chamber 6 having the common bath 2 and heat recovery unit 7 supported thereon and being extended into said chamber 6. The heat recovery unit 7 is provided to recover the heat energy from the flew gases passing therethrough. A level control means for example a flot valve 8 is provided with the common water bath 2 for maintaing the water level in the water bath by supplying the water automatically from the heat recovery unit 7. A temperature indicator 9 is provided with the heat recovery unit to show the temperature of the unit. The gasifier is provided on one side of the chamber 6 for producing and supplying producer gas by burning fuel like wood therein.

Reference is now made to fig.2. The heat recovery

unit comprises a plurality of pipes 10 made of stainless steel tubes, disposed into an insulated drum 11 of any shape (cylinderical shape) and for conveying flew gases therethrough. The drum 11 is provided for containg liquid medium/water therein. A water inlet 12 is provided to supply water into the drum 11. A drain 13 is provided near the bottom of the drum 11 to drain out water therefrom as and when required. A gaze glass 14 is provided near the top end of the drum 11 to indicate the water level in the drum. A sliding dom 15 having a chimney 16 therewith is mounted over the top end of the drum 11 for facilitating the exit of the flew gases.

The gasifier 4 according to this invention has a metallic cylindrical reactor 17 having a feeding hopper 18 provided thereon. The combustion/reaction zone of the reactor 17 is provided with the line refractories (not shown) an inlet is provided to supply the air into the combustion zone required for producing the producer gas. The air is supplied by means of a blower (not shown). An air supply pipe 19 is provided to suppi, the air in the burner for facilitating the burning of producer gas. An ash pit tank 20 is provided below the reaction 17 for conver.ing the ash received from the gasifier into charcoal.

Reference is now made to fig.4 wherein the cooking/heat recovery system is of the same construction as shown in fig.2 except the construction of the heat recovery unit 7. As shown in fig.4 the heat recovery unit comprises heat recovery drum 21 of any shape preferably of cylinderical shape disposed in an insultated outer chamber 22 in a spaced relationship with the insulated chamber 22 so as to provide a passage 23 therebetween for the passage of the flue gasses therethrough.

WE CLAIM

1) A cooking/heat recovery device comprising a plurality of perforated cooking pots supported on a common bath, a burner adapted to be connected with a gasifier being provided for heating said common bath, a heat recovery unit being provided adjoining to the cooking bath such that to utilize the heat energy entrapped in the flue gases, a level control means being provided with the said cooking bath such that to control the level of the water in the cooking bath, a gasifier being provided on one side of said common bath for producing and supplying producer gases to said burner.

2) A device as claimed in claim 1 wherein said common cooking bath and heat recovery unit are supported on an insulated sealed chamber and being extended into it.

3) A device as claimed in claim 1 wherein said heat recovery unit comprising a plurality of conveying tubes disposed into an insulated drum for the passes of the flew gases therethrough so as to recover the heat from the gases for heating the water contained in the

drum, water inlet is provided near the top end of the drum for a supply of water therein, a drain being provided at the bottom end of said drum for draining the water therefrom.

4. A device as claimed in claim 3 wherein in a gaze glass is provided neat the top end of for monitoring the water level in the drum.

5. A device as claimed in claims 1,3 and 4 is sliding dom having a chimney provided at the top end thereof being provided over the top end of said drum for facilitating the exit of the flew gases.

6. A device as claimed in claim 1 wherein an air supply pipe from the blower is provided with the burner for facilitating the burning of the producing gas.

7. A device as claimed in any of the claims 1 to 6 wherein said heat recovery unit comprises a hea recovery cylinder disposed in an insulated outer chambe in a spaced relationship with said insulated chamber.

8. A cooking oven/heat recovery device as herein described and illustrated.

Dated 3rd June, 1998.

(R.P. YADAV)
OF L.S. DAVAR & CO.
APPLICANTS' ATTORNEY.

Applicant's Name: TATA ENERGY RESEARCH INSTITUTE.

Total sheets
Sheet No. 1

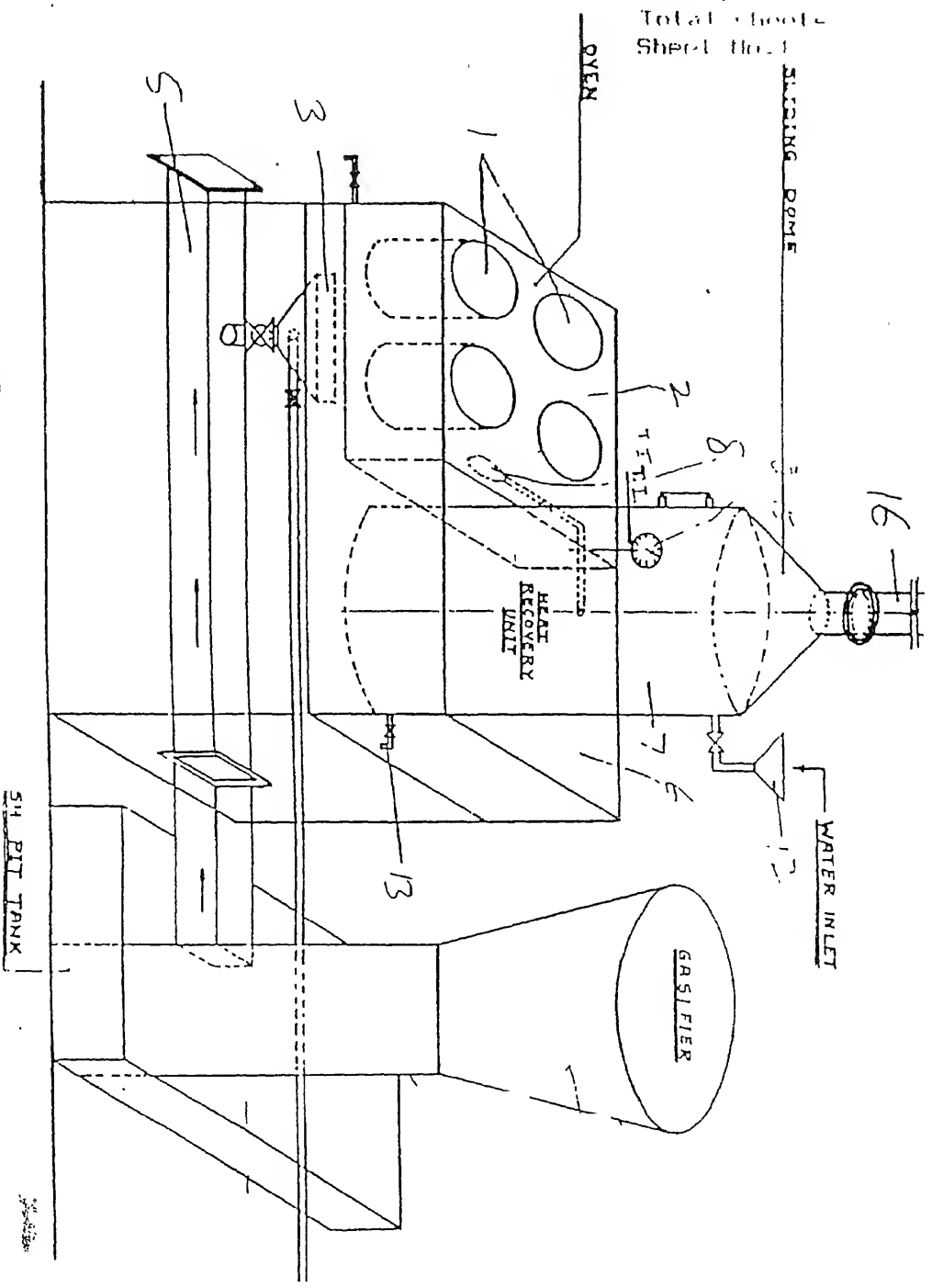


Fig - 1

(R.P. YADAV)
OF L.S. DAVAR & CO.,
APPLICANTS ATTORNEY.

Applicant's Name: TATA ENERGY RESEARCH INSTITUTE.

Total sheets 3
Sheet No.2

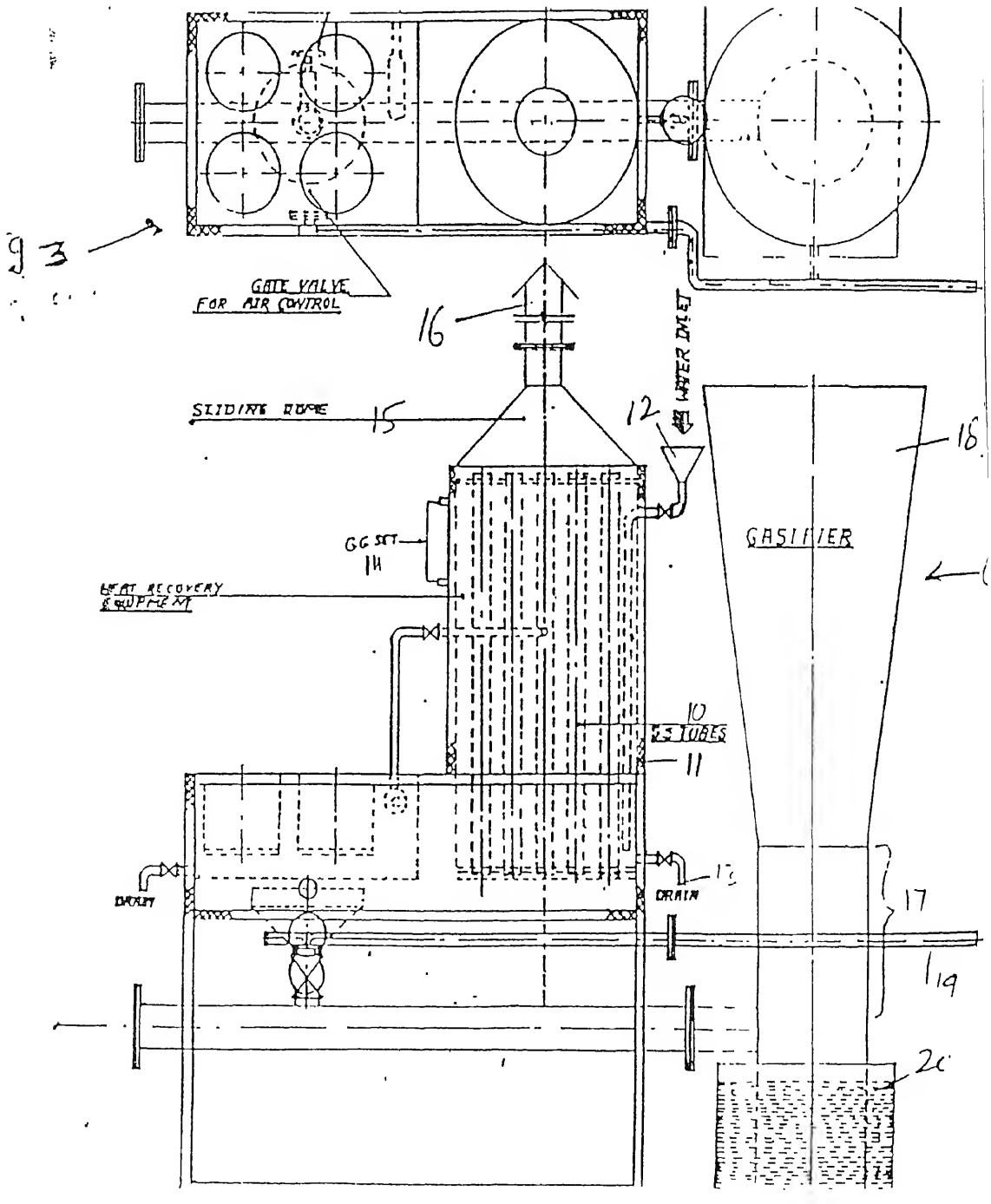


Fig-2

Applicant's Name: TATA ENERGY RESEARCH INSTITUTE.

Total sheets 3

Sheet No.3